FINAL DRAFT

Future Water Use Projections for the Middle Rio Grande Water Planning Region

September 2001

This report was prepared by the Middle Rio Grande Council of Governments staff, working in collaboration with the Middle Rio Grande Water Assembly; and was supported in part by funding from the New Mexico Interstate Stream Commission.

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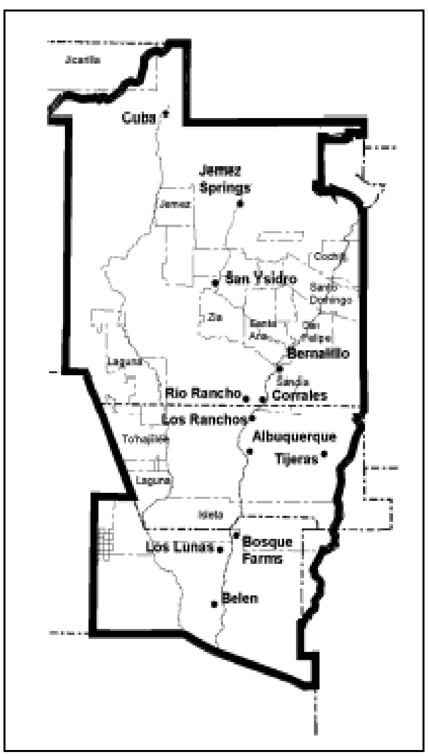
Executive Summary

The Middle Rio Grande Water Planning Region is one of 16 water-planning regions in New Mexico. The planning region essentially consists of Sandoval, Bernalillo, and Valencia counties, an area encompassing 5,495 square miles. The planning region includes various federally owned lands as well as lands belonging to 13 different Native American Governments. The planning region includes all of the Jemez River watershed and portions of the Rio Grande and Rio Puerco watersheds. The planning region is subdivided along the boundaries of these watersheds.

Figure ES-1 - The Middle Rio Grande Water Planning Region



The Middle Rio Grande faces challenges of growing population, expanding urbanization, and increasing demands for scarce water. It is an arid region, averaging only 9 inches of rain per year. The Rio Grande, lifeblood for many, not only provides water to our region, but to many others both upstream and downstream. Two countries, three states, and several Native American entities rely on its waters. Our region alone contains three watersheds, each with its own characteristics and problems. Within this Middle Rio Grande water planning region, there are 13 Native American governments, three counties and several municipalities, each with varying responsibilities for managing water resources. The task of balancing water use and availability is necessary to maintain the quality of life throughout the region.

The Middle Rio Grande water-planning region is not alone in having to balance increasing demands for water. The State of New Mexico encourages regional water planning to manage those demands. In keeping with this effort, our region has undertaken the development of such a plan. In so doing, we are attempting to answer some basic questions:

- What is our available water supply?
- What historic demands have we made and are we presently making upon the water supply?
- What demands do we expect will be made upon the water supply in the next 40 years?
- How will we meet the future demands with supply?

The first two questions have been considered in other reports, and in the final plan the last question is to be addressed, with the alternatives reflecting the region's goals and objectives. The purpose of this report is to anticipate what the future demands on the water resource will be. The estimated demands are based upon projected trends in population growth and changes in land use, and are described in terms of withdrawals[1] and depletions[2]. Some variations of projections have been devised in order to illustrate a range of future water usage and the subsequent impacts on water supply. However, the primary purpose is to present a reference baseline of our future water situation given our current land and water management practices and the trends that exist today.

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[1] Withdrawal: water that is either diverted from the surface-water system or pumped from wells. Some of this water may return to either the surface-water or groundwater system.

[2] Depletion: that part of a withdrawal that has been evaporated, transpired, or incorporated into crops or products, consumed by people or livestock, or otherwise removed from the water environment. It includes the portion of ground-water recharge resulting from seepage or deep percolation (in connection with a water use) that is not economically recoverable in a reasonable number of years, or is not usable. Same as consumptive use.

Present Day Water Supply and Use

The population of the planning region has increased by 21% over the past 10 years, from 589 thousand to more than 712 thousand residents. Despite a decline in irrigated agriculture, our water supplies are already stretched to, or beyond, their limits. The water supplies of the Middle Rio Grande region have been documented in a number of reports prepared over the last several years. A group of technical experts, working on behalf of the Middle Rio Grande Water Assembly, prepared a water budget for the Middle Rio Grande region in 1999. Their report, entitled *Middle Rio Grande Water Budget*, was based on average flows for the period from 1972 to 1997. The report concluded that:

- We are depleting our reserves of groundwater in the region by approximately 70,000 acre-feet[3] per year.

Another report, entitled *Middle Rio Grande Water Supply Study*, was completed by the firm S.S. Papadopulos & Associates, Incorporated, in August 2000 for the U.S. Army Corps of Engineers and the New Mexico Interstate Stream Commission. This latter report concluded that:

- On average, the present water supply is barely adequate (including San Juan-Chama Project water and groundwater withdrawals) to meet the present demands in the Middle Rio Grande region, and

- The water supply is highly variable, due to the high variability in Otowi inflow[4] and the high variability in evaporation from the Elephant Butte Reservoir.

In the report entitled *Historical And Current Water Use In The Middle Rio Grande Region*, prepared by John Shomaker & Associates, Inc. together with PioneerWest in June 2000, our current (as of 1995) regional water use was assessed. The Shomaker

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[3] An acre-foot is the amount of water required to cover an acre (43,560 square feet) to a depth of one foot and equal to 325,851 gallons.

[4] Otowi inflow is the amount of water flowing in the Rio Grande at the Otowi stream gage located at the river crossing on the road between Santa Fe and Los Alamos.

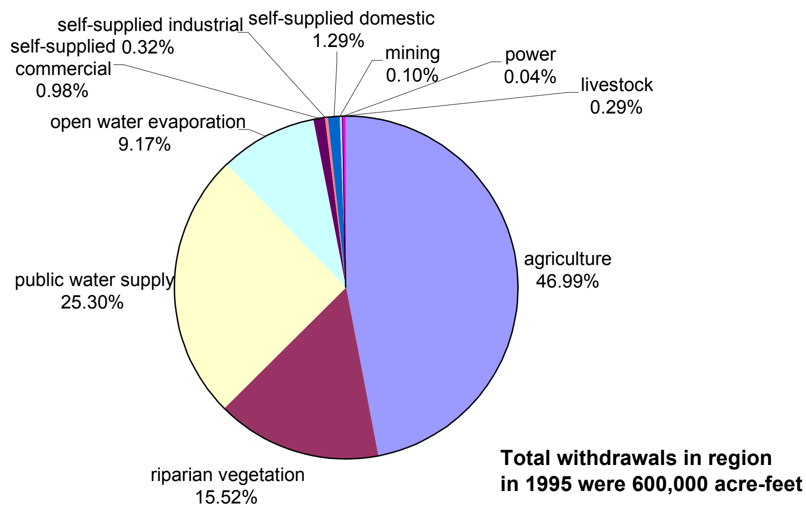
report utilized an adaptation of the water use categories defined by the State Engineer. Shomaker reported the withdrawals and consumptive use[5] of water under the following categories: public water supply, riparian vegetation, agriculture, livestock, power, mining, self-supplied domestic, self-supplied industrial, self-supplied commercial, and open water evaporation.

Shomaker concluded that:

- total withdrawals in the planning region in 1995 were 600,000 acre-feet
- total depletions (consumptive use) in the planning region in 1995 were 340,000 acre-feet.

The relative proportions of withdrawals reported by Shomaker are shown in Figure ES-2. This figure illustrates the significance of agriculture, riparian vegetation, public water supply, and open water evaporation as the major withdrawals in the region.

Figure ES-2 - Distribution of withdrawals by category in total region, 1995



Reference: Shomaker report, Figure 50 on page 88

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[5] Consumptive use means depletion.

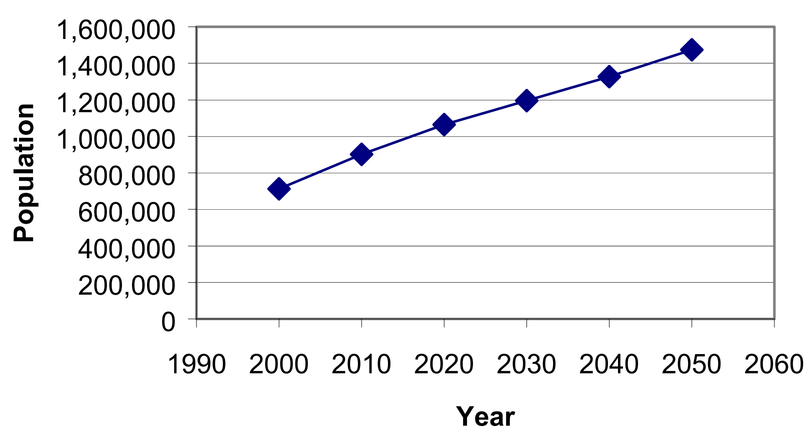
Land Use and Future Projections

The Middle Rio Grande Council of Governments (MRGCOG) created an initial regional land-use map using 1996 as the base year for the *Focus 2050 Regional Plan* project. The purpose of the Focus 2050 project was "to create a long-range strategy for managing growth and development within the region through the year 2050" (Resolution of Board of Directors, February 10, 2000). MRGCOG's regional land-use map includes 18 land-use categories.

Water withdrawal and depletion coefficients for the land use categories were derived by correlating water-use information, as reported by Shomaker, with the land-use categories developed by MRGCOG.

Projections of future withdrawals and depletions were calculated by combining withdrawal and depletion coefficients with a map of future land uses. The future land-use map used for this project was prepared in conjunction with the Focus 2050 project. This future is based on a projected future population of 1.47 million people in the planning region and assuming a continuation of the current trends in land development. The population projections used to calculate future water use are shown in Figure ES-3.

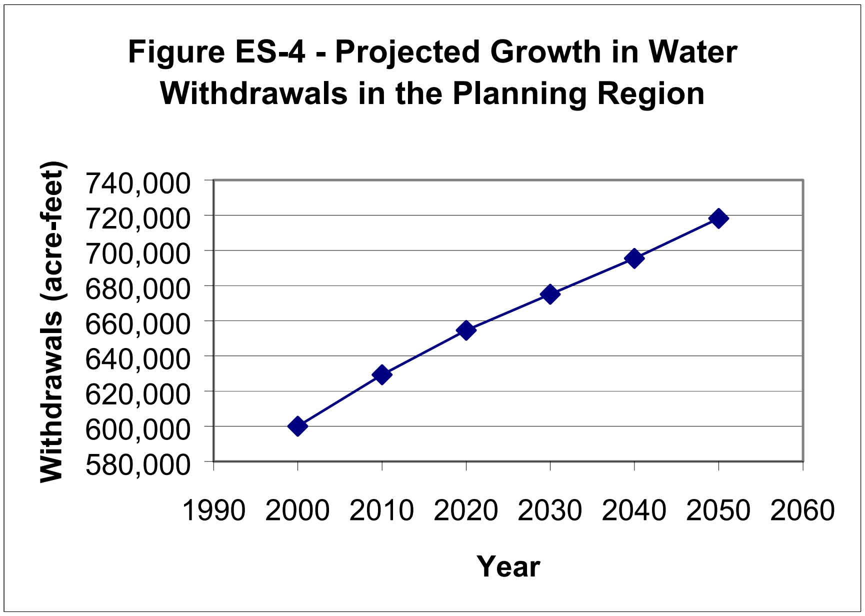
Figure ES-3 - Projected Population Growth in the Planning Region



Significant factors influencing future water use include population and economic growth and anticipated decreases in irrigated agriculture. The projected withdrawals calculated at 10-year intervals of time for each of the regional land-use categories considered in this study are shown in Table ES-1. (Note: The numbers displayed in this table are not a representation of accuracy, but are the direct result of multiplying withdrawal coefficients by a specified amount of land under a specified land use category.) Also, as a comparison to the projected population growth, the projected water withdrawals for the region as a whole are shown in Figure ES-4.

Table ES-1 – Projected withdrawals at 10-year intervals for the planning region

	Withdrawals (acre-feet)					
Land-Use Category	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Single-family residential	108,557	146,451	179,297	205,803	232,265	261,680
Multi-family residential	10,000	11,670	13,117	14,285	15,451	16,747
Major retail commercial	2,451	2,658	2,837	2,982	3,126	3,287
Mixed and minor commercial	19,149	23,382	27,051	30,012	32,967	36,253
Office	2,042	3,001	3,832	4,502	5,172	5,916
Industrial and wholesale	5,865	6,535	7,116	7,585	8,053	8,573
Institutions	1,602	1,690	1,767	1,829	1,890	1,959
Schools and universities	3,069	2,979	2,900	2,837	2,774	2,704
Airports	5,123	4,894	4,696	4,536	4,376	4,198
Transportation and major utility corridors	591	570	552	537	522	506
Irrigated agriculture	281,934	265,568	251,383	239,936	228,508	215,804
Rangeland and dry agriculture	0	0	0	0	0	0
Major open space and parks (with water use)	5,001	4,795	4,616	4,471	4,327	4,167
Major open space and parks (no water use)	0	0	0	0	0	0
Natural drainage and riparian systems	148,140	148,198	148,248	148,288	148,328	148,373
Urban vacant and abandoned	0	0	0	0	0	0
Landfills and sewage treatment plants	2,131	2,164	2,193	2,216	2,239	2,265
Other urban non-residential	1,347	1,697	2,001	2,246	2,490	2,762
Kirtland Air Force Base	3,000	3,002	3,004	3,005	3,006	3,008
Totals:	**600,002**	**629,254**	**654,608**	**675,069**	**695,496**	**718,202**



The forecast for future withdrawals shown in Figure ES-4 correlates directly with the slope of the graph shown in Figure ES-3, given the base case projection for water planning purposes in the Middle Rio Grande region. Again, this implies a decrease in irrigated agriculture associated with an increase in population, with no changes in water management. The base-case projection indicates that regional withdrawals could increase to 718 thousand acre-feet per year by the year 2050, an increase of 20% compared to current withdrawals. This projection will be used in future efforts to evaluate the effects of potential water-supply and water-management alternatives.

In addition to the base-case projection, several variations were calculated to show a range of potential projections for the future. In one variation, agricultural acreage was held constant rather than being reduced by the projected 8,800 acres as assumed in the base case projection. In two other variations, various levels of conservation (15% and 33%) were examined. These variations to the base-case projection indicate that if we were to stabilize our withdrawals at the current level, we may have to reduce our per capita consumption by 33% by the year 2050. In order to meet the goal of the regional water plan, balancing our use with renewable supply, then we will have to reduce total water consumption in the region even further.

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Forward

by Frank Titus, Middle Rio Grande Water Assembly

June 6, 2001

This document is a fundamental early part of what ultimately will be a regional water plan for the Middle Rio Grande Region. (The "Region," as designated for this water planning, is only the upper 150 miles or so of the more conventionally known “Middle Rio Grande Valley” — the “Region” is that part contained within Sandoval, Bernalillo and Valencia counties.) This part of the plan provides information and data on the present and the estimated future demand for water by the major water-user groups (human, faunal, floral and inanimate). Hence, it is an essential building block for developing a functional plan that will allow us to live within our water means.

Why is regional water planning being undertaken? The state legislature has instructed that such plans be developed for each of sixteen regions throughout the state, and it gave oversight and limited funding assistance for the regional efforts to the New Mexico Interstate Stream Commission. The format and content of this section are intended to meet the guidelines and specific requirements of the Interstate Stream Commission. Though the report is based on data that can be argued to be from the most reliable projections of population growth and urban expansion, the reader must accept that all such projections are, in the final analysis, educated guesses about the future. Nevertheless, the numbers and the conclusions herein will provide a reasonable foundation on which to build a plan for optimizing the use and distribution of available water as urban and rural environments evolve.

Developing a plan for managing the water future of such a complex region is a daunting task. People who know water in New Mexico and in the Rio Grande say, with virtually no dissent, that the Middle Rio Grande region currently uses on average all of the water it has rights to use. The rest must be left in the river to flow downstream to other users who also have water rights. This means that any new water use added to existing demands must be balanced by a reduction somewhere else in this system. It is a tough circumstance, but real, permanent, and not changeable. The reason it is permanent and not changeable, of course, is that New Mexico in 1938 became a party to the Rio Grande Compact, which specifies numerically how water is to be divided among Colorado, New Mexico and Texas. This contract, to which the federal government is a mandatory party, cannot be violated. Nor can it be modified without unanimous agreement.

If every new use will require that some existing use be forgone, how are we to decide who gives up what? Excellent question! What about "the marketplace" deciding? Unfettered, development will build over the valley floor, Albuquerque and Rio Rancho will buy up the "pre-1907" water rights, groundwater mining will accelerate, and ultimately the Rio Grande will be put in a concrete channel to assure delivery downstream under the Rio Grande Compact rather than have its flows leak into expanding "cones of depression" around pumping wells. That actually is the pathway we are well established on, with some of the main marketplace players being the cities' decision-makers, the developers, and those farmers willing to sell their few pre-1907 water rights.

So, what's the difference now? Why should there now be regional planning? The difference is it finally has become clear to all that we have no choice but to make tradeoffs. As a result, various new players have entered the game. Advocates for endangered species have sued; the US Bureau of Reclamation and other feds have staked out positions; the Middle Rio Grande Conservancy District has come forward as a hopeful water banker; and numerous self-styled, ad hoc action groups now campaign for their respective preferences. And that's only a partial list. But one sad principle remains intact: so far it appears that not a single entity has been willing to enter into give-and-take negotiations with others. There is talk about tradeoffs, but so far no functional trading.

The aim of this regional water-planning effort is to provide an open forum wherein stakeholders of every conceivable stripe can participate in creating a pragmatic yet equitable plan that substantially influences what our future environments and our future quality of life will be in this region.

Time grows short for formulating a balanced plan. Right now we are not in the midst of a crisis. So we have time to decide among ourselves the best and most equitable way to share the burdens of living within our water means. We New Mexican's have had several water wake-up calls — like our loss in the US Supreme Court to Texas over failure to deliver water we owed on the Pecos River. This has cost us more than $50 million so far, and it is far, far from over. If, come the next major drought, we fail to deliver what we owe on the Rio Grande, the Pecos costs will prove to be peanuts. And besides, fully two thirds of what we Mid-Rio residents are supposed to deliver past

Elephant Butte Dam under the Compact is for our fellow New Mexicans in the vicinity of Hatch and Las Cruces.

What we decide to do in the Middle Rio Grande Valley, specifically including the area of our regional water planning, will be the major determinant for living within our water means in both average and drought conditions. Much more importantly, it virtually will be the sole determinant of what our part of the Land of Enchantment will look like as our sons and daughters, and theirs, grow up and take over. Are we going to leave them an environment that we've pulled together cooperatively to create, or that we've pulled apart? Will the river still be the Great River? And will this region still be like, New Mexico?

Future Water Use Projections for the Middle Rio Grande Water Planning Region

Introduction

Purpose and Scope

The purpose of this report is to provide estimates of the future demand for water in the Middle Rio Grande region. The region's need for water in the future is an important component of the water plan to be developed for this region. The projections of future water demand that are documented in this report are developed from historical trends of population growth, water use, and water management in both the planning region and the state.

The projections described in this report are referred to as the "base case" future water demands for the region. The "base case" is an assessment of the magnitude of our region's water needs in the future that assumes, among other things, that recent trends in population growth along with a decline in irrigated agricultural acreage will continue into the future and that sufficient water supplies will be available to meet the projected increase in demand. The "base case" assumes that water will be managed and used in the future just as it is today.

However, there are a number of reasons to suggest that water will be managed and used differently in the future. Most of these reasons derive from the highly variable amount of "renewable" water supplied by the Rio Grande, the increasing scarcity of water in our region, and the growing competition for access to surface and ground water. It is distinctly possible, even probable, that water will be managed more efficiently in the future and that conservation and technology will reduce the amount of water needed for many uses. Thus, the "base case" probably represents an upper limit for the amount of water needed in the future assuming the level of growth and development projected to occur, and the hypothetical availability of supply necessary to meet that demand.

Significant work has already been completed on the water supplies available to the Middle Rio Grande Region. Historical and current water demands have also been documented. These studies demonstrate that there is already an imbalance between water supply and demand in our region. A growing imbalance between supply and demand may bring about new trends in the way that water is used in our region, or influence existing trends, such as water conservation, to be amplified beyond their current levels.

It should be clear from the foregoing discussion that the “base case” projection of future water demands is not the solution to the reported imbalance between present water supply and demand. The “base case” is merely a reference baseline for attempting to evaluate and manage our future water situation. Against this baseline, we may evaluate the effects of possible changes to our behavior and public policy. The “base case” can be thought of as a starting point for developing sound water management alternatives and strategies. As a starting point, the base-case projection provides a useful index against which alternatives and strategies can be compared to measure their effectiveness in balancing supply and demand. The Middle Rio Grande regional water planning process, through technical effort and public dialogue, will be considering, and eventually recommending, changes to our water-related behavior and public policies. The recommendations will be evaluated by considering their social, environmental, legal, economic and other effects.

Legal constraints of critical importance in assessing future water use include the 1938 Rio Grande Compact between Colorado, New Mexico, Texas, and the United States. The Rio Grande Compact commits New Mexico to deliver most of the water flow in the Rio Grande valley from the Otowi Gage located south of the City of Espanola downstream into Elephant Butte Reservoir. Some of the significance of the obligations and limits imposed by the Rio Grande Compact is apparent when compared with current and historical water demand in the region. Although all of the municipalities within the region along the Rio Grande presently rely on water from below the ground for supplying drinking water, these waters are hydrologically connected to the river and other surface water supply in ways that are the subject of ongoing investigation and study.

There is uncertainty related to a number of the assumptions used to forecast future water demands. Some of these uncertainties are identified and discussed in this report. Because of the uncertainty associated with these assumptions, a range of values for future water demands is presented in this report. A base-case projection of future water demands is presented in the main text of this report. This projection is based on trends in land uses and population growth, assuming no new water conservation measures. In addition to the base-case projection, several variations of the base-case projection are also presented in Appendix C. These variations are presented to evaluate future water demands with somewhat different assumptions concerning future land uses and management of water demands. The variations of the base-case projection should not be viewed as planning alternatives, but rather as estimates of the potential range of future water demands given the uncertainties in the assumptions used to calculate such a projection. Thus, the variations from the base-case projection provide a type of sensitivity analysis for several of the assumptions used in the projections.

The projected water demands are presented as average annual water demands. Average demands are based on both wet and dry periods of time. Fluctuations in annual water demands in our region are influenced by the amounts of rainfall during the growing season (March through October). An exceptionally wet growing season can substantially decrease the amount of water needed for crop and landscape irrigation compared to an exceptionally dry year. Urban and suburban water demands also vary from year to year. For example, water demands currently vary as much as 5 percent above and below the average for the City of Albuquerque's public water supply system depending upon climatic factors (Jean Witherspoon, personal communication). Such year-to-year variations are likely to be typical of other public water suppliers in the region.

Background and Previous Work

The historical and current water use in the Middle Rio Grande Region was described in a report prepared by Shomaker & Associates, Incorporated and PioneerWest (June 2000). This report, referred herein as the Shomaker report, documented historic and current water withdrawals and depletions for the region as a whole and for sub-portions of the region. Some of the issues related to water planning in the region were discussed in "Water Resource Planning in the Middle Rio Grande Region, A Background for Water Planning and Summary of Representative Issues" (Gross, August 2000).

The Shomaker report identified withdrawals and consumptive use by categories consistent with categories used by the U. S. Geological Survey, the New Mexico Office of the State Engineer, and the Interstate Stream Commission. These categories included: (1) public water supply, (2) self-supplied domestic, (3) irrigated agriculture, (4) self-supplied livestock, (5) self-supplied commercial, (6) self-supplied industrial, (7) self-supplied mining, (8) self-supplied power, (9) open-water evaporation, and (10) riparian consumptive use. However, four of these categories account for more than 97 percent of total consumptive use in the region as of 1995, the most recent year for widely available water-use data in the region. In order of descending value these categories are riparian consumptive use (29%), irrigated agriculture (28%), public water supply (25%), and open-water evaporation (16%). These four categories of water use are projected to continue to be the major categories of water use within the region for the foreseeable future.

Description of the Planning Region

New Mexico's water-planning regions are partly defined by shared water resources and partly by shared political and economic interests. There are currently 16 water-planning regions in New Mexico. Planning is underway at some level in all of the 16 water-planning regions of New Mexico. New Mexico's water planning regions are shown in Figure 1.

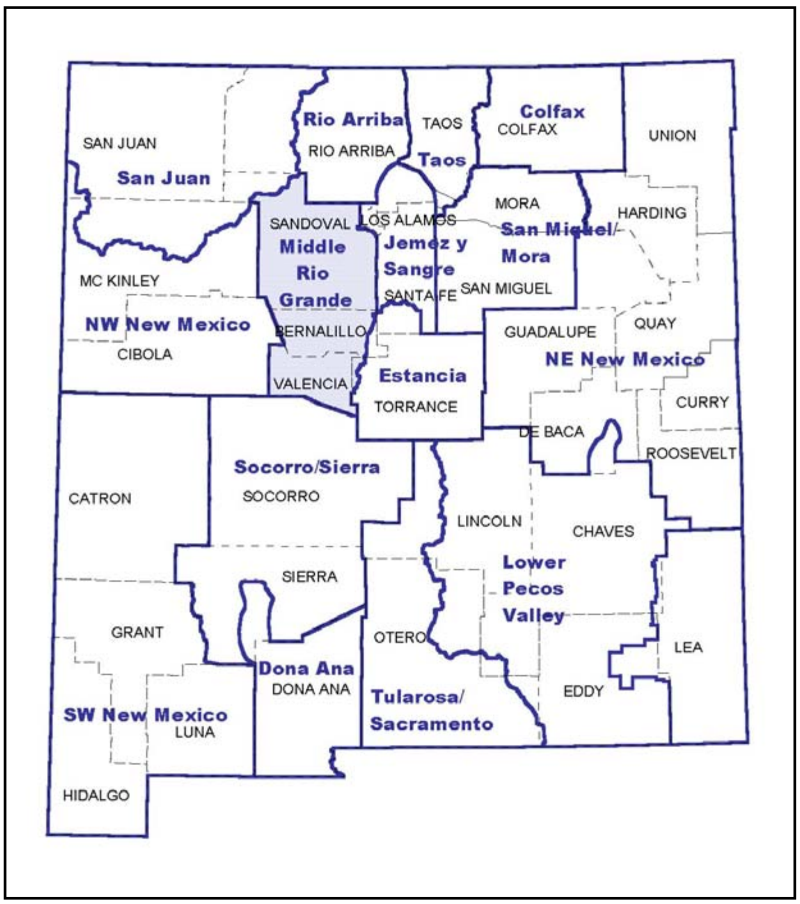

Figure 1 - New Mexico's Water Planning Regions

Solid lines show planning region boundaries. Lighter dashed lines show county boundaries.

Planning Region Boundaries and Subregions

The Middle Rio Grande Water Planning Region largely consists of an area within the boundaries of Sandoval, Bernalillo, and Valencia counties. Both public and private lands lie within the planning region. Publicly held lands are managed by a variety of federal, state, and local agencies. The principal federal land-management agencies include the U.S. Bureau of Land Management and the U.S. Forest Service. A land status map for the planning region is shown on Plate 1 at the end of the report. All or portions of 13 Native American reservation lands lie within the boundaries of the Middle Rio Grande Water Planning Region. Native American lands within the region are shown on Plate 2. The Middle Rio Grande Water Planning Region has the largest population of any region in New Mexico. Approximately 712 thousand people lived within the water-planning region in the year 2000.

All of Valencia County and most of Bernalillo and Sandoval counties lie within the planning region. The easternmost portion of Bernalillo County that drains into the Estancia Basin is included within the Estancia Basin Planning Region. A small portion of northern Sandoval County is situated west of the continental divide and drains to the San Juan River which is part of the Colorado River Basin. This northern portion of Sandoval County is part of the San Juan Water Planning Region. As noted above, a small portion of Torrance County on the western slope of the Manzano Mountains is also included in the Middle Rio Grande Water Planning region. The total area of the planning region is approximately 5,495 square miles. The Middle Rio Grande Water Planning Region is shown in Figure 2.

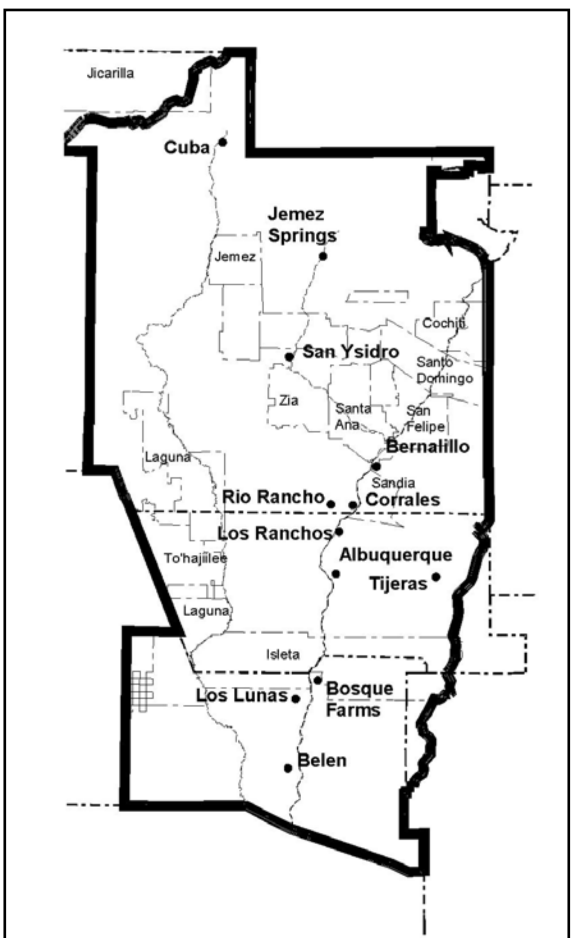

Figure 2 – The Middle Rio Grande Water Planning Region

The planning region includes all of Valencia County and most of Bernalillo and Sandoval counties. A small portion of Torrance County in the western slope of the Manzano Mountains is also within the planning region.

For planning purposes, the Middle Rio Grande Region is divided into 3 subregions: (1) the Rio Jemez subregion, (2) the Rio Puerco subregion, and (3) the Rio Grande Valley subregion. These subregions are shown in Figure 3.

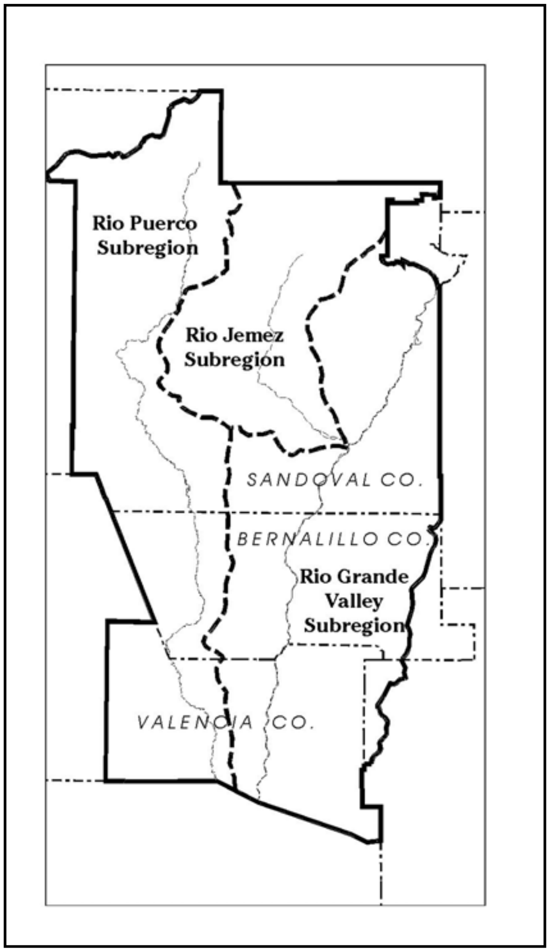

Figure 3 – Water Planning Subregions

The Middle Rio Grande Water Planning Region includes the Rio Jemez, Rio Puerco, and Rio Grande Valley subregions.

The Rio Jemez subregion lies entirely within Sandoval County and includes the watershed area of the Jemez River down to its confluence with the Rio Grande. The Rio Jemez subregion, with an area of about 1,017 square miles, occupies approximately 18% of the total planning region.

The Rio Puerco subregion extends through Sandoval, Bernalillo, and Valencia Counties. It occupies the Rio Puerco watershed within these counties, and has an area of about 2,119 square miles. The Rio Puerco subregion occupies approximately 39% of the total planning region.

The Rio Grande Valley subregion occupies the easternmost portion of the planning region in Sandoval, Bernalillo, and Valencia counties. It includes a portion of Torrance County on the western slope of the Manzano Mountains. The Rio Grande Valley subregion has an area of about 2,359 square miles, or 43% of the total planning region.

The Middle Rio Grande Water Planning Region is adjacent to 5 other water-planning regions as shown in Figure 1. The neighboring water-planning regions are the Rio Arriba planning region to the north, the Jemez y Sangre to the northeast, the Estancia Basin to the southeast, the Socorro/Sierra to the south, the Northwest New Mexico to the west, and the San Juan water-planning region to the northwest. Two of the neighboring water-planning regions, Jemez y Sangre and Socorro/Sierra, include reaches of the Rio Grande. The Northwest New Mexico and Socorro/Sierra water-planning regions include portions of the Rio Puerco watershed. A small portion of the Rio Jemez watershed lies within the Rio Arriba water-planning region.

The entire Middle Rio Grande water-planning region drains to the Rio Grande. The boundaries of the subregions are largely coincident with surface-water hydrologic unit boundaries. Most of the planning region lies within the Rio Grande groundwater administrative basin as designated by the New Mexico State Engineer. A portion of the San Juan groundwater administrative basin occurs in the northwest portion of the planning region, and a portion of the Sandia groundwater administrative basin occurs in eastern Bernalillo County. Groundwater flows out of the Sandia groundwater administrative basin into the Rio Grande administrative groundwater basin. Plate 3 shows the location of surface water hydrologic units and groundwater administrative basins in the planning region.

Physical Characteristics

Elevations in the region range from slightly below 5,000 feet in the Rio Grande Valley at the southern boundary of Valencia County to 11,254 feet on Redondo Peak in the Jemez Mountains. Mean annual precipitation varies from approximately 6 inches in the lower elevations of Valencia County to approximately 30 inches at the higher elevations of the Jemez, Sandia, and Sierra Nacimiento mountains. Most of the planning region is very arid, receiving less than 10 inches of precipitation per year. Most of the precipitation in the lower elevations occurs from thunderstorms in mid to late summer. Summer thunderstorms bring rainfall to the higher elevations as well, but these higher areas also receive a significant portion of their annual precipitation as winter snowfall.

Water Resources

The Rio Grande has been an important source of water for New Mexico and its neighbors for some time, and there have been a number of studies characterizing the surface-water supply of the Rio Grande. Surface water has been principally used for irrigation in the region; however, there are projects underway to utilize surface water for municipal drinking water supplies. Groundwater supplies are also important along the Rio Grande. Groundwater has historically been the primary source of urban and suburban water supplies in recent times. A number of studies have been completed characterizing the groundwater supply, particularly along the Rio Grande Valley. Less information is available characterizing groundwater supplies outside of the Rio Grande Valley.

Surface-water supplies in the planning region include the Rio Grande, a number of rivers tributary to the Rio Grande within the planning region, and surface water imported into the basin. The average annual inflow of native water in the Rio Grande at the Otowi gage is approximately 1.1 million acre-feet (three acre-feet of water is approximately equal to 1 million gallons of water). A study prepared for the Action Committee of the Middle Rio Grande Water Assembly (1999) estimated that the average tributary inflow to the Rio Grande between Otowi gage and Elephant Butte Reservoir is estimated to be approximately 95,000 acre-feet per year.

The Interstate Stream Commission and the U.S. Army Corps of Engineers recently commissioned a study of the water supply for the Rio Grande region (S.S. Papadopulos & Associates, Inc, August 2000). The study area for the report is from Cochiti Reservoir to Elephant Butte Reservoir. The study found that the Rio Jemez and the Rio Puerco contribute the largest tributary flows to the Rio Grande within the planning region. The average flow of the Jemez River is estimated to be approximately 55,000 acre-feet per year near Jemez and approximately 44,000 acre-feet per year below the Jemez Canyon Dam. The Jemez Canyon Dam is located on the Jemez River approximately 2.5 miles upstream from where the Jemez River joins the Rio Grande. The average flow of the Rio Puerco where it joins the Rio Grande is approximately 32,000 acre-feet per year. The report concludes that the present water supply is barely adequate to meet present uses of water while continuing to meet obligations to deliver water to downstream users.

In addition to native water inflow, the San Juan / Chama Diversion Project yielded approximately 55,000 acre-feet of water per year in recent years, although the Project water has not been fully utilized by the entities who have contracted for this water. The San Juan/Chama Project brings water from the Colorado River Basin into the Rio Grande Basin, and hence this water is not characterized as native to the Rio Grande Basin.

Ground-water supplies underlying the Rio Grande Valley and adjacent areas have been studied in some depth in recent years. The City of Albuquerque and the U.S. Geological Survey have sponsored much of the work as a cooperative effort; and have focused on the Middle Rio Grande Basin, a groundwater basin that extends from Cochiti Reservoir on the north to San Acacia (south of Valencia County) on the south. This basin is also known as the Albuquerque-Belen Basin or simply as the Albuquerque

Basin. The Middle Rio Grande Basin is approximately 100 miles in length and generally ranges from 25 to 35 miles in width. The basin has an area of slightly more than 3,000 square miles. Most of the basin lies within the Middle Rio Grande Water Planning Region; however, a portion of the basin extends somewhat to the south of the region. The location and boundaries of the Middle Rio Grande Basin are shown in Figure 4.

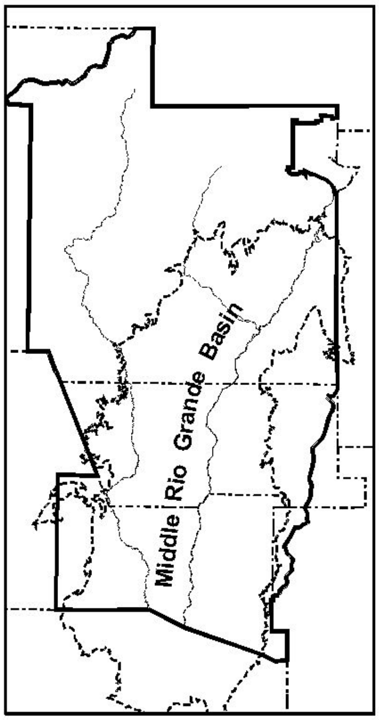

Figure 4 – The Middle Rio Grande Groundwater Basin

The Middle Rio Grande Basin is a geologic basin filled with sediments. The most productive aquifers in the planning region are found within the basin.

The Middle Rio Grande Basin is filled with sand, silt, clay, and gravel. These materials, or sediments, filled the basin over long periods of time as the center of the basin subsided. The thickness of these sediments varies. In some parts of the basin the sediments are deeper than 10,000 feet. However, recent studies indicate that only the uppermost sediments appear to be useful as aquifers. This is because the deeper sediments are often too fine-grained to yield significant quantities of water, and because the water quality at greater depths is generally poor. The depth of productive aquifers in the basin is generally less than 2,000 feet over most of the basin. In places the depth of productive aquifers is less than 2,000 feet.

Groundwater in the Middle Rio Grande Basin is replenished both by underflow from areas adjacent to the basin and by groundwater recharge. Recharge is the movement of water from the land surface into the aquifer. Much of the recharge to the basin occurs at the outer margins of the basin along the mountain fronts. Underflow and recharge cannot be measured directly. Scientists must rely on estimates for many of the factors that are used to calculate underflow and recharge. Work completed in the mid 1990's suggested that replenishment to the basin is approximately 188,000 acre-feet per year (Thorn, McAda, and Kernodle, 1993). More recent work undertaken by the U.S. Geological Survey has suggested that recharge may be significantly less.

Major Influences on Future Water Demand

There are a number of potential influences that can cause future water demand to change compared to current rates. Billings and Jones (1996) cite a number of major factors influencing urban and suburban water demands including population, economic cycles, technology, weather and climate, price, and conservation. Physical deterioration of the water distribution system can also affect urban and suburban water demands. These same factors can also influence agricultural water demands, although local changes in population may not be as significant of a factor for agricultural water demands. Future changes in the size and configuration of riparian systems and surface-water bodies can also influence future regional depletions.

Some of these influences are more significant than others when considering long-range projections. Population growth is a significant factor because our region, like most of the southwestern United States, has been experiencing continuing increases in population for several decades. The rate of population increase in our region may decline in the future, but there is little evidence to suggest that our regional population will stop growing.

Economic cycles are also a factor influencing water demand. People may tend to use more water when they have more money. However, economic cycles tend to average out over the long term. Therefore, economic cycles are not considered as a separate factor in this report. Likewise, the physical condition of water distribution facilities is not considered as a separate factor influencing long-range projections. System losses are considered to be a continuing characteristic of water distribution systems, and it is assumed for purposes of this report that individual water purveyors will continue to manage their systems much as they do today.

The effect of technology on long-term projections is variable. For example, some technological changes in the home such as garbage disposals and dishwashers have probably served to increase household water use. Other innovations such as low-flow plumbing fixtures have served to decrease household water use. Overall, it seems more likely that future technological innovations will be associated with more efficient uses of water. Therefore, for purposes of this report the influence of technology is considered to be one of several factors related to future water conservation measures.

Weather and climate are influences on many categories of water demands at time scales ranging from days to years. Daily and monthly variations are especially important for sizing water production, treatment, and distribution facilities. Water demands in our region also vary from year to year as a result of variations in precipitation. However, these variations have not been separated and analyzed at a regional scale for the historic and current water demands. Further work would be needed in this area before such variations can be applied at the regional scale, particularly using a land-use approach to forecast water demands.

Numerous studies have established a significant influence of price on water demand, particularly case studies of regional droughts where the cost of marginal supplies has been substantially higher than normal supplies. It would be possible to calculate the price elasticity of demand for different types of water use in the Middle Rio Grande, holding all other variables constant, but no individualized analyses have been reported for this region. A report prepared for the City of Albuquerque (Brown, Nunn, Shomaker, Woodard, 1996) approached this subject, but did not undertake a firm quantification. Because such information is sparse, price is considered to be one of several conservation factors which could be targeted in future alternatives but is not explicitly analyzed in this report. Two different levels of future water conservation, expressed as percent decreases in withdrawal coefficients compared to current levels, are evaluated in this report and are presented in Appendix C.

Depletions related to riparian consumption and open-water evaporation are a large part of the overall water budget in the region. They are estimated to be approximately 148,000 acre-feet per year on average in the Shomaker report. Even incremental changes in these categories of depletions could yield significant changes in the overall water budget for the region. Changes in water management practices such as the amount and timing of releases of water from storage and artificial flooding for environmental purposes have the potential to increase evapotranspiration and open-water evaporation. Removal of exotic vegetation and replanting with native species appears to have potential to reduce evapotranspiration. Water management changes such as these are already the subject of litigation or are subject to potential litigation, making it difficult to predict future depletions for riparian systems and open-water evaporation. Because of the uncertainty associated with such altered water management practices, evapotranspiration and open-water evaporation are held constant for the purposes of this report.

Population Growth

Population growth is an important factor anticipated to influence growth in water demand in New Mexico and in the region. Population growth is generally associated with increases in demand for public water-supply uses, commercial water uses, and industrial water uses. Population growth, positive or negative, is a function of fertility, mortality, and migration. In turn, these factors are at least partially dependent upon other factors such as the health of the national and regional economies, the relative cost of living for the region, and opportunities for employment. Other less tangible factors, sometimes referred to as quality of life factors, also affect population growth.

Population growth rates in New Mexico and in the planning region have been variable over the last 100 years. United States Census Bureau counts for New Mexico have documented population increases for every 10-year census since 1880. Population growth rates in New Mexico since 1880 have ranged from 7 to 67 percent for succeeding 10-year intervals of time. The variations in historic population growth rates for New Mexico are somewhat less if 40-year intervals of time are used to average the growth rates. U.S. Census Bureau data show growth rates ranging from 15 to 43 percent for 40-year periods of time since 1890.

The most recent Census Bureau data for New Mexico shows that the State population increased by 20 percent during the 1990's. The population for the 3-county water planning region increased by 21 percent during the same period. By comparison, the increase in population for the United States during 1990's was approximately 13 percent. However, nearly all the mountain west portion of the continental United States is growing faster than the U.S. average. Arizona, Colorado, and Texas, the principal states bordering New Mexico, grew faster than New Mexico did during the 1990's. The fastest growing state, Arizona, grew from 3.6 million to 5.1 million people during this time, a 40% increase in population. Table 1 shows recent population data for New Mexico and the 3-county planning region. A population density map showing the approximate distribution of the regional population in 1995 is shown on Plate 4.

Table 1 - Recent population in New Mexico and the planning region

Area	1990 Population[6]	1995 Population[7]	2000 Population[8]	Increase 1990 to 2000
Bernalillo County	480,577	524,820	556,678	16 %
Sandoval County	63,319	79,268	89,908	42 %
Valencia County	45,235	56,833	66,152	46 %
3-County Planning Region	589,131	660,921	712,738	21 %
New Mexico	1,515,069	1,685,401	1,819,046	20 %

Population projections were prepared for the Focus 2050 Regional Plan project (Middle Rio Grande Council of Governments, February 2000). These projections were based in part on projections prepared by the Bureau of Business and Economic Research at the University of New Mexico, and the Bureau of Economic Analysis, a division of the United States Department of Commerce. Focus 2050 estimated that the combined population for Bernalillo, Sandoval, and Valencia counties would be approximately 1.49 million people in the year 2050. The Board of Directors of the Middle Rio Grande Council of Governments adopted the Focus 2050 population projections in February 2000. A population density map showing the approximate distribution of the projected population in 2050 is shown on Plate 5.

The Middle Rio Grande Council of Governments calculated three forecasts for the population of the water planning region in the year 2050 using different using demographic data and varying assumptions for socioeconomic data. The three forecasts for the future population are 1.14, 1.18, and 1.47 million people. The future land-use map used in this report is based on an assumed future population of 1.47 million people in the planning region and a continuation of the current trends in land development. It should be noted that the different population projections calculated for this report do not have probabilities associated with them. Therefore, the medium projection is not necessarily more probable than the either the low or the high projections. Details of the population projections and the methods used to obtain them are included in Appendix A.

[6] U.S. Census 1990 data
[7] MRGCOG Population Estimates
[8] U.S. Census 2000 data

Current Trends in Agriculture

Much of the information used in this section of the report was obtained at a meeting held at the Department of Agricultural Economics and Agricultural Business at New Mexico State University on February 5, 2001. The purposes of the meeting were: (1) to discuss the important factors influencing agriculture in New Mexico today, and, based on these factors, (2) to make forecasts for what is likely to occur in the future for agriculture. Participants in the meeting included Professors Lowell Catlett, Jerry Hawkes, Jim Libbin, and Rhonda Skaggs. This information from this meeting is partly factual and partly professional opinion. It used in this report to help establish likely trends and conditions for future agricultural water uses.

Much of the irrigated agriculture within the planning region occurs within the Middle Rio Grande Conservancy District. There are also locally significant areas of irrigated agriculture within the Rio Jemez and Rio Puerco subregions. Plate 5 is a map showing agricultural water uses in the planning region including the locations of groundwater and surface-water diversions.

The Split Personality of Agriculture

Agriculture in the United States and in New Mexico is becoming increasingly characterized by a dual-farm structure. This structure is composed of: (1) a small number of very large farms, and (2) an increasing number of much smaller farms that are operated by people with sources of income other than the farm (Skaggs and Wiltgen, September 2000). Typically, the other sources of income for small farmers are full-time or part-time jobs off the farm. This means that the operators of small farms generally do not spend all of their time operating their farms. The trend towards a dual-farm structure is associated with a general decline in the number of medium-sized farms. In New Mexico, particularly in areas nearby growing urban centers, the trend is typically toward an increasing number of small farms operated on a part-time basis.

Farm Profitability

Large farms in the United States are operated to make a profit. Small-scale farms on the other hand often do not make a profit, and they may operate at a net loss. Small-scale agriculture in New Mexico has roots in the Pueblo and Hispanic cultures of our region, but it is also becoming a choice for many people who do not want to live in the city. The choice to engage in small-scale farming is often more related to cultural and lifestyle preferences than to business or economic opportunities. Very few farms in New Mexico actually make a profit, especially the smaller farms. (Skaggs and Wiltgen, September 2000) reported on the distribution of farms in New Mexico by value of sales. They found that consistently negative net farm income characterizes farms in all sales categories except the largest. Farms with high sales categories represent only a very small percentage of the total farms in New Mexico. Thus, it is likely that very few farms in the Middle Rio Grande have a net positive income.

Significant Factors Influencing Agriculture

Availability of Labor. Farm labor is a limiting factor today in New Mexico and in the Middle Rio Grande water-planning region. The limited availability of farm labor can sometimes lead to incomplete harvests of crops that are grown today. The limited availability of farm labor is not only true for New Mexico, which gets some of its farm labor from the vicinity of El Paso and Juarez, but also for farming operations in Mexico. Thus, the limited availability of labor is a regional factor, and it is likely to be even more significant in the future. The availability of farm labor is a significant factor for farmers in the selection of crops. Farmers are increasingly likely to move away from crops that require intensive labor for production and select crops that require less labor.

Strong Market for Alfalfa. Alfalfa hay is one of the principal irrigated crops grown in New Mexico. It was the number one crop in New Mexico in 1998 based on harvested acreage (U.S Department of Agriculture and the New Mexico Department of Agriculture). The Middle Rio Grande region has a strong demand for alfalfa, and it may be a net importer of alfalfa. The strong demand for alfalfa is likely to continue into the future because of an expected trend towards greater numbers of livestock (horses and cattle) on an increasing number of small farms. People who keep a few horses and/or a few head of cattle are often willing to pay significantly more for alfalfa than a feedlot or dairy.

Competition with other Growing Regions. Apples, grapes, and many other specialty crops are not likely to increase significantly in New Mexico or the planning region because of competition from other large growing areas such as California and Washington. However, there is likely to be a continued small market for locally grown, specialty products such as these and other crops.

Water Conservation. There has been much discussion about opportunities for farmers to use less water to grow crops in our region; however, it is not likely that farmers will voluntarily change to low-volume irrigation systems for several reasons: (1)

irrigation water from surface-water sources is generally inexpensive, (2) low-volume irrigation systems, such as drip irrigation, are expensive and problematic, and (3) under existing law governing water rights, farmers could potentially lose a portion of their water rights by using less water. It seems likely that farmers will continue to irrigate their crops in the future much as they do today. However, there could be incentives in the future for farmers to change to lower-volume irrigation systems if they can sell or lease water in lieu of using it to grow crops.

Forecast for Agriculture

Crops. Alfalfa may continue to be the principal cash crop planted in the planning region for a variety of reasons. It is inexpensive to plant, grow, and harvest. It requires little labor, and so farmers who hold part-time or full-time jobs off the farm can grow it. Alfalfa requires minimal use of pesticides, and therefore does not have large environmental impacts. Most importantly, it is expected that there will be a continuing strong demand for alfalfa within the region into the foreseeable future, and that prices for alfalfa may even rise in the future as the nature of the market for alfalfa changes. These factors indicate that alfalfa could occupy an even greater share of the irrigated acreage of the region in the future.

There is a good potential for the nursery industry to expand as the regional population grows. However, with the trend towards increased use of xeriscape, it is not likely that this sector will use greatly increased amounts of water compared to today. Some nursery products have a greater potential to be grown locally, because they are difficult to transport long distances. Poinsettia plants are an example.

Small amounts of vegetables, organically-grown produce, and other specialty crops are likely to continue to be grown in the planning region. There is a potential for other higher-value crops to be grown in the region; however, it is not expected that such crops will be a large component of total farming for the planning region in the future.

Farming and Water Management. The amount of irrigated lands has been declining due to conversion of irrigated lands to urban uses. This trend is expected to continue in the future. In addition, there may be a general decline in the average size of farms in the region as is occurring elsewhere in New Mexico and the United States. In general, the smaller farms are not expected to be economically viable enterprises on their own, although farming operations growing higher-valued crops may continue to be successful business enterprises. Operators of small farms are likely to rely increasingly on sources of income off the farm to support themselves and their families. Thus, it is expected that the overall health of the economy will likely play a greater role in the health of farming. It does not appear that there will be an increase in large-scale farms in the region. Also, food production in New Mexico and in the planning region is not a significant factor in the availability or price of food in New Mexico or in the water-planning region.

Irrigation practices for alfalfa in the future are likely to be the same as they are today, unless there are new incentives for farmers to irrigate differently. However, there may be strong incentives for farmers to consider selling and/or leasing water, especially if water prices rise significantly compared to today's prices.

There are still major questions about the true basin-wide water savings that might result from moving to lower-volume irrigation systems. It may be more likely that water transfers in the future will be related to temporary or permanent retirement of agricultural lands rather than the installation of low-volume irrigation systems.

Increases in intensive or large-scale agricultural operations, especially animal feedlots and dairies, are not likely to be a part of the Middle Rio Grande water planning region in the future. These types of business are likely to move to other parts of the state or even out of New Mexico. The primary reasons include typical nuisance objections of nearby residents in urbanizing areas (e.g. smell and flies), as well as the higher costs for land and taxes in such areas.

Methodology

Spatial-Analysis Approach

Projections of future water demands for regional water planning have typically been approached by examining historic trends in the factors influencing water demands. Total population growth is usually a surrogate parameter for growth in total public water supply projections. Similarly, historic trends in agricultural production are often used as a surrogate for projecting future irrigation water uses. Economic models are sometimes combined with historic trends to derive more sophisticated projections. For example, the impact of an international treaty dealing with agricultural trade might be to decrease the price of a certain commodity. The decline in the price of that commodity might be linked to a forecast decline in local production of that commodity. These approaches do not require a planner to know precisely where in the region future water uses will occur. Only the change in water use is needed to derive a total future water demand forecast.

Although such approaches are valid and useful, there has been a growing sentiment nationwide that there needs to be a better connection between land-use and water-use planning. The organization 1000 Friends of New Mexico has argued that land-use planning and water planning must be connected, and growth and development must be consistent with those plans. Planners and government officials have noted a disconnect between land-use planning and water-resource planning for some time, but they have not necessarily agreed upon how a connection can or should be made.

A spatial-analysis approach to estimating water demands using geographic information systems (GIS) and land-use mapping is one way to obtain a closer connection between land-use planning and water planning. This type of spatial-analysis approach to calculating future water demands is somewhat more difficult to construct than an approach based solely on projected demographic and economic trends, partially because there isn't a one-to-one correlation between land-use categories and water-use information. In addition, lands classified within a single land-use category may have widely differing rates of water use. However, there can be some merit in developing a spatial-analysis approach for estimating regional water demands, particularly if changes in the location of water uses have varying impacts on the quantity and/or quality of water resources. Planners are often interested in the hydrologic impacts of future growth, including the impacts of increased water withdrawals and return flows. Hydrologists can help them understand such impacts using spatially-based hydrologic models (Modflow for example) if the planners can provide the hydrologists with reasonable configurations for future land uses. There may also be some merit in developing a spatial-analysis approach if changes in land uses affect water resource management alternatives.

This report utilizes a spatial-analysis approach, or land-use approach, for predicting future water demand by applying factors for converting land use activities into units of water withdrawal and depletion. The approach used in this report combines historic and projected trends in water uses with a spatial analysis approach to calculate future water demands.

The methodology used to develop withdrawal coefficients for this report essentially involves four steps: (1) correlating measured and estimated water uses with each of the mapped land-use units for existing conditions, (2) calculating the areas for each of the existing land-use units, (3) calculating withdrawal coefficients for each of the land-use map units from their areas and corresponding withdrawals, and (4) calculating total future regional water withdrawals from their respective coefficients and a future land use map. A more detailed outline of the approach to develop withdrawal coefficients is presented below.

A. <u>Develop a Correlation between Land Uses and Water Withdrawals</u>
   1. Identify mapped land use categories and their areas
   2. Identify water use categories with available information
   3. Assign water use categories to one or more land use categories
   4. Establish a test area for developing initial withdrawal coefficients
   5. Calculate areas of land uses within the test area
   6. Adjust withdrawal coefficients ($m^3/[m^2 \times t]$) for land uses to match known water uses in test region
   7. Calculate water uses for entire planning region and compare to known values for entire region
   8. Adjust withdrawal coefficients at a regional scale to better match total known values for water uses in the region

B. <u>Develop Projection for Base-Case (no new conservation) Projection</u>
   1. Develop map of future land uses at the planning horizon (Landuse Analysis Model)
   2. Calculate water uses for the entire planning region

C. <u>Develop Variations of the Base-Case Projection</u>
   1. Identify variations to be evaluated
   2. Estimate the impact of trends on land and water uses
   3. Recalculate total water use.

D. <u>Develop Projections for 10-year Increments of Withdrawals</u>

1. Develop 10-year-interval population projections within planning horizon
2. Calculate water uses for each land-use category based population projection and on interpolation to planning-horizon values.
3. Aggregate all water uses at 10-year increments to planning horizon.

The future land-use map that is used for this project is the trend-scenario land-use map that was developed for the Focus 2050 project. This land-use map is based on population projections that are very similar to the high population projection that was prepared for the current project. The map is also based on a continuation of the land development patterns existing today. Water demand projections at 10-year intervals of time and represented as withdrawals were also calculated based on population projections and changes in the forecast amounts of irrigated agriculture. The approach used to calculate depletion coefficients is outlined later in this report.

Assumptions and Uncertainties Associated with a Land-Use Approach

The withdrawal coefficients derived for this analysis represent average values of water use for each of the land-use categories in the planning region. The units used to express these coefficients in this report are gallons per acre per day; however, any dimensionally equivalent unit could be used. Units of feet per year are more common for irrigated agriculture. Units of gallons per acre per day can be converted to feet per year by dividing the former by 893.

The more land-use types that are available, the more detailed the withdrawal coefficients can theoretically be. However, greater detail in specifying withdrawal coefficients does not necessarily translate into greater accuracy in forecasting water demands using a land-use approach, primarily because the corresponding details for water-use data as they apply to typical land-use categories simply do not exist.

Withdrawal coefficients are likely to change over time. For example, the City of Albuquerque is currently striving to decrease its aggregate per capita water demand by 30 percent compared to its 1995 rate of 250 gallons per capita per day. Aggregate per capita water demand is the total water supplied by City sources for all uses divided by the total population served by the City. The City’s target aggregate per capita water use with a 30 percent reduction would be 175 gallons per capita per day. Albuquerque hopes to achieve its aggregate per capita water use with conservation in all categories of water use.

Conservation measures for residential water uses are likely to cause withdrawal coefficients for residential land uses to decline in the future. For example, the City of Albuquerque already has incentives to replace high-water-use landscapes with xeriscape and to replace older plumbing fixtures with newer, more efficient ones. In addition, the new housing in the region generally uses more xeriscape than the older housing and includes higher-efficiency plumbing fixtures. Thus, residential water use per dwelling unit is expected to decline in the future.

Similarly, existing water conservation measures are likely to increase the efficiencies of other types of water uses, such as commercial and industrial uses, causing the withdrawal coefficients for other land uses to decline in the future. Thus, the base-case projection is likely to be an upper estimate of water use at the planning horizon.

It is anticipated that urban and suburban water demand can be managed to decrease per capita demand. However, urban and suburban water demand management programs usually include a mix of components such as educational programs, media attention, voluntary conservation measures, mandatory conservation measures, and pricing incentives. It is difficult to isolate the respective contributions of individual program components with respect to the overall reduction in water demand. Thus, it becomes somewhat problematic to model individual components. Nevertheless, demand management programs should be capable of reducing per capita demand by as much as 50%, at least on a short-term basis, compared to water demand prior to implementation of demand management.

Urban and suburban water demand per unit area per unit time may also vary for reasons other than demand management. Dwelling unit density, dwelling unit vacancy rates, lot size, and household size are variables that can influence the withdrawal coefficients for residential land uses. Household sizes are declining nationwide and are expected to decrease in our region from an estimated 2.61 persons per household in 1995 to 2.38 in 2050. Assuming no change in outdoor water uses for the same kind of housing, the decrease in household size alone could represents as much as a 9% decrease in indoor water use, and a 5% overall decrease in residential water use per dwelling unit.

Land-Use and Water-Use Categories Used in this Analysis

Land-Use Categories

Nineteen regional land-use categories are used for this report. These are largely consistent with the 18 land-use categories used by the Middle Rio Grande Council of Governments; however, major open space and parks was subdivided into two categories for this report: (1) major open space and parks with water use, and (2) major open space and parks with no water use. Descriptions of the land-use categories follow:

Single-Family Residential. Detached dwelling units normally occupied by one family. This includes mobile homes and mobile home parks, some home-based commercial businesses, especially in rural areas, and townhouses built as separate units. Farm buildings are included in the category if they cover an area of one acre or larger. Yard space and accessory buildings associated with single-family residences are included in this category.

Multi-Family Residential. Attached dwelling units within a structure normally occupied by more than one family. This includes apartment complexes with two or more units, group living situations such as retirement homes, convents, monasteries, dormitories, and residential hotels. The lands and accessory buildings associated with these structures are also included in this category.

Major Retail Commercial. Large commercial businesses that serve a regional market. This category includes mixed uses (e.g. retail, office, hotels, and scattered residential uses) occurring in an urban center (such as downtown Albuquerque), large shopping malls, and large businesses such as “big box” retail or an auto dealership.

Mixed and Minor Commercial. Small commercial retail, service, and other mixed uses that generally serve a local market such as a neighborhood or a small town. Mixed uses may include light industry, small offices, and scattered dwellings. Hotels and motels not located in an urban center are included in this category.

Office. Large professional or governmental office complexes that serve a regional market area. Large banks and trade schools are included in this category. This category may also include smaller offices, and mixed uses (e.g. scattered residential, restaurants, and other retail and commercial services within regional centers).

Industrial and Wholesale. Large industrial, wholesale warehouse and distribution businesses. This category may include heavy commercial, dispersed, and auxiliary services, and scattered residences within industrial areas. Examples of land uses in this category are large manufacturing operations, power plants, auto repair and salvage, scrap metal yards, and industrial parks.

Institutions. Large specialized governmental or private institutions that serve a large population base. This category includes state fairgrounds, detention centers, hospitals, military bases, and convalescent and nursing homes.

Schools and Universities. Public and private schools and university campuses and lands associated with these uses such as athletic fields and playgrounds. This category does not include commercial trade schools such as real estate or beauty schools.

Airports. Terminal buildings, hangars, runways, heliports, and associated structures. FAA Air Traffic Control Centers not located at an airport are not included in this category.

Transportation and Major Utility Corridors. Major roads, railroads, corridors for major pipelines and large electrical transmission lines, major flood control diversion channels within the Albuquerque area, and private and public right of way.

Irrigated Agriculture. Irrigated field crops such as alfalfa, chile, wheat, and corn. Indoor and outdoor commercial horticultural operations, orchards, and truck gardens. This category may include some non-irrigated and fallow agriculture.

Rangeland and Dry Agriculture. Non-irrigated grazing lands, desert scrub, fallow and idle agriculture, stock pens, corrals and stables. This category may include scattered residences and some irrigated agriculture.

Major Open Space and Parks (with water use). Urban open space, neighborhood or community parks, plazas, pedestrian malls, and public sports facilities such as sports arenas, golf courses, and swimming pools. In general, this category includes open space, parks, and recreational facilities that include at least some irrigation. This land-use category was created for this project from the existing land-use coverage created by the Middle Rio Grande Council of Governments. The category was created by separating areas with at least some water use, particularly irrigation uses, from those that had no water use or very small water use.

Major Open Space and Parks (no water use). Federal, state, and municipal open spaces and recreations areas, including state parks, U.S. Forest Service lands, and national monuments. In general, this category includes open space and parks that have no water use or very small water use. This land-use category represents the original major open space and parks land-use category used by the Middle Rio Grande Council of Governments less those areas separated as being irrigated. The Albuquerque Open Space area and U.S. Forest Service lands are examples of lands in this category.

Natural Drainage and Riparian Systems. The Rio Grande and the Jemez River channels including the adjacent areas dominated by riparian vegetation, such as cottonwood, salt cedar, and riparian shrubs, known locally as the Bosque, except where this is an established recreation area (e.g. Rio Grande State Park). Irrigation canals and drains of various widths, including the miscellaneous grass, shrubs, and trees growing along them. This category also includes undeveloped areas dominated by riparian vegetation, open water and marshes, and lined and unlined arroyos at least 50 feet wide, which function in the conveyance of storm water runoff. This category does not include major flood control diversion channels in the Albuquerque area.

Urban Vacant and Abandoned. Completely vacant land and/or land containing abandoned structures in urban environments.

Landfills and Sewage Treatment Plants. Sewage treatment plants, ponding sites, solid waste disposal facilities, landfills and refuse collection centers, and incineration and composting plants.

Other Urban Non-Residential. Churches, cemeteries, crematoriums, funeral homes, public and private museums and libraries, and public assembly facilities.

Kirtland Air Force Base. All lands on Kirtland Air Force Base.

Water-Use Categories

The water-use categories used in this report are generally consistent with the categories of water use as currently used by the U.S. Geological Survey, the New Mexico Office of the State Engineer, and the New Mexico Interstate Stream Commission. The water-use categories include: public water supply, self-supplied domestic, self-supplied commercial, self-supplied industrial, self-supplied mining, self-supplied power, irrigated agriculture, self-supplied livestock. The definitions of these water-use categories are provided in Technical Report 49 from the New Mexico State's Office (Wilson and Lucero, 1997). The Shomaker report included two additional categories: open-water evaporation and riparian consumptive use. These are also included in this report.

In addition to these water-use categories, the City of Albuquerque was able to provide a breakdown of its public water-supply uses into 4 components based on its billing system: (1) residential, (2) commercial, (3) industrial, and (4) institutional. Furthermore, the City reported that approximately a third of its commercial water accounts are water provided to apartments and mobile home parks.

Land-Use Maps

Existing Land-Use Map

The Middle Rio Grande Council of Governments created a map of existing regional land uses in conjunction with the Focus 2050 project. The land-use map was originally prepared to reflect land uses as of 1996. However, staff at the Middle Rio Grande Council of Governments has updated the existing land-use map to reflect land uses as of the year 2000. In particular, updated geographic information from the City of Albuquerque and the City of Rio Rancho was incorporated into the existing land-use map. The year 2000 existing land-use map used in this report is shown on Plate 7. Total areas for each of the land-use categories by county and by subregion, rounded to the nearest acre, are shown in Tables 2 and 3.

Shomaker used information from the New Mexico Office of the State Engineer (Saavedra, 1987) to report irrigated acreage by subregion. The total acreage for irrigated agriculture in the Rio Grande Valley subregion derived from the Middle Rio Grande Council of Government's existing land-use map is relatively consistent with the total irrigated acreage reported in the Shomaker report. Shomaker reported 36,765 acres of irrigated land for the Rio Grande Valley subregion using the 1987 State Engineer report. However, irrigated acreages for the Rio Jemez and Rio Puerco subregions derived from the existing land-use map are lower than acreages reported by Shomaker using the 1987 report. Shomaker reported acreages of 1,223 and 3,267 for irrigated agriculture in the Rio Jemez and Rio Puerco subregions, respectively. The discrepancy could be due to errors in the Middle Rio Grande Council of Government's existing land-use map, or it could be that irrigated acreage in the Rio Jemez and Rio Puerco subregions has decreased since the State Engineer collected data for the report it published in 1987.

Table 2 – Areas of existing land uses in the planning region and by county (in acres)

Land-Use Category	Bernalillo County	Sandoval County	Valencia County	Torrance County	Planning Region
Single-family residential	58,760	18,663	17,076	0	94,499
Multi-family residential	3,484	199	80	0	3,763
Major retail commercial	1,064	48	0	0	1,112
Mixed and minor commercial	6,985	867	836	0	8,688
Office	916	10	0	0	926
Industrial and wholesale	6,736	1,063	603	0	8,402
Institutions	673	129	1,288	0	2,090
Schools and universities	2,925	482	595	0	4,002
Airports	6,310	29	341	0	6,680
Transportation and major utility corridors	188	315	268	0	771
Irrigated agriculture	5,202	7,863	24,451	0	37,516
Rangeland and dry agriculture	410,741	1,616,983	600,231	18,352	2,646,307
Major open space and parks (with water use)	4,980	1,149	392	0	6,521
Major open space and parks (no water use)	88,968	423,119	16,222	22,022	550,331
Natural drainage and riparian systems	11,888	19,923	10,729	0	42,540
Urban vacant and abandoned	19,975	19,545	1,272	0	40,792
Landfills and sewage treatment plants	1,828	233	718	0	2,779
Other urban non-residential	1,281	188	287	0	1,756
Kirtland Air Force Base	30,695	0	0	0	30,695
Totals:	663,599	2,110,808	675,389	40,374	3,490,170

Table 3 – Areas of existing land uses in the planning region by subregion (in acres)

Land-Use Category	Rio Grande Valley	Rio Jemez	Rio Puerco
Single-family residential	91,598	1,400	1,502
Multi-family residential	3,763	0	0
Major retail commercial	1,112	0	0
Mixed and minor commercial	8,508	131	50
Office	927	0	0
Industrial and wholesale	8,261	80	63
Institutions	1,978	109	2
Schools and universities	3,945	10	47
Airports	6,651	0	29
Transportation and major utility corridors	762	8	0
Irrigated agriculture	36,377	586	553
Rangeland and dry agriculture	938,671	432,055	1,275,581
Major open space and parks (with water use)	6,521	0	0
Major open space and parks (no water use)	273,052	207,724	69,554
Natural drainage and riparian systems	35,403	7,012	125
Urban vacant and abandoned	40,653	98	40
Landfills and sewage treatment plants	1,357	8	1,414
Other urban non-residential	1,709	19	28
Kirtland Air Force Base	30,695	0	0
Totals:	1,491,493	649,240	1,348,988

Future Land-Use Map

A map of future land uses was created for the Focus 2050 Regional Plan. The future land-use map was generated using a model developed for the Middle Rio Grande Council of Governments by Planning Technologies of Albuquerque, New Mexico. The Land-Use Analysis Model (LAM) utilizes demographic and geographic information to forecast a future distribution of land uses within a given study region. Geographic input information needed by the model includes: (1) an existing land use map, (2) a land-use plan, and (3) a map of projects that are in the development process and have a reasonable expectation of being built. Demographic information input to the model includes housing and employment forecasts. Although housing and employment forecasts are totals for the region, LAM does have the capability to allocate portions of these control totals to subareas of the region. LAM is essentially a disaggregation model in that it takes forecasts for total regional employment and housing needs, and simulates land use patterns consistent with these totals and consistent with the geographic information inputs. The LAM User's Guide (Planning Technologies, 1998), prepared for the Middle Rio Grande Council of Governments, provides documentation of model input and how the model works. The future land-use map is shown on Plate 8. Total areas for each of the land-use categories by county and by subregion, rounded to the nearest acre, are shown in Tables 4 and 5.

It should be understood that the version of the existing land-use map used to generate the future land-use map for the Focus 2050 project was based on information as of 1996. The Middle Rio Grande Council of Governments has continued to update the existing land-use map, incorporating changes in land uses since 1996 and correcting errors in the data. The updates and corrections have changed the areas for some land-use categories on the current version of the existing land-use map. Consequently, the areas for some land-use categories on the future land-use map do not appear to be consistent with the current version of the existing land-use map. In general, the changes in areas for land-use categories resulting from the updates and corrections were most significant for the land-use categories with smaller total areas such as institutions, schools and universities, airports, transportation and major utility corridors, and landfills and sewage treatment plants. However, the total area of these particular land-use categories is less than 1 percent of the total area of the planning region, and the total calculated water use associated with these particular land-use categories is less than 2 percent of the total water use for the planning region. Thus, any errors in calculating future water withdrawals associated with the updates and corrections to the existing land-use map are not considered to be significant for regional interpretation.

Table 4 – Areas of future land uses in the planning region and by county (in acres)

Land-Use Category	Bernalillo County	Sandoval County	Valencia County	Torrance County	Planning Region
Single-family residential	94,020	87,818	45,986	0	227,824
Multi-family residential	3,913	1,504	886	0	6,303
Major retail commercial	1,295	186	11	0	1,492
Mixed and minor commercial	11,552	2,663	2,238	0	16,453
Office	2,153	153	379	0	2,685
Industrial and wholesale	9,342	1,802	1,142	0	12,286
Institutions	1,867	331	356	0	2,554
Schools and universities	2,887	338	301	0	3,526
Airports	5,351	37	88	0	5,476
Transportation and major utility corridors	160	287	212	0	659
Irrigated agriculture	4,502	7,478	16,740	0	28,720
Rangeland and dry agriculture	371,543	1,558,476	577,953	18,342	2,526,314
Major open space and parks (with water use)	4,469	621	344	0	5,434
Major open space and parks (no water use)	88,594	423,076	16,062	22,034	549,766
Natural drainage and riparian systems	11,824	20,072	10,717	0	42,613
Urban vacant and abandoned	14,544	5,141	525	0	20,210
Landfills and sewage treatment plants	2,150	82	722	0	2,954
Other urban non-residential	2,499	592	511	0	3,602
Kirtland Air Force Base	30,777	0	0	0	30,777
Totals:	663,442	2,110,657	675,173	40,376	3,489,648

Table 5 – Areas of future land uses in the planning region by subregion (in acres)

Land-Use Category	Rio Grande Valley	Rio Jemez	Rio Puerco
Single-family residential	220,553	4,263	3,008
Multi-family residential	6,302	0	0
Major retail commercial	1,492	0	0
Mixed and minor commercial	15,890	187	376
Office	2,564	30	91
Industrial and wholesale	12,110	86	89
Institutions	2,438	117	0
Schools and universities	3,472	7	46
Airports	5,439	0	37
Transportation and major utility corridors	651	8	0
Irrigated agriculture	27,675	491	554
Rangeland and dry agriculture	824,022	428,923	1,273,367
Major open space and parks (with water use)	5,434	0	0
Major open space and parks (no water use)	272,303	207,838	69,625
Natural drainage and riparian systems	35,521	6,965	126
Urban vacant and abandoned	20,080	92	36
Landfills and sewage treatment plants	1,553	6	1,395
Other urban non-residential	3,283	78	241
Kirtland Air Force Base	30,777	0	0
Totals:	1,491,559	649,091	1,348,991

Correlation between Land-Use Categories and Water-Use Categories

A test area equivalent to the water service area for the City of Albuquerque was established for developing initial withdrawal coefficients for the land-use categories. Because the City of Albuquerque has detailed water use data, relative values of water-use coefficients could be estimated and then calibrated to regional water use. Water service provider areas for the larger public water service providers in the region were also compiled and digitized for this project. The areas were digitized using maps, sketches, and descriptions provided by the utilities. Areas served by community water systems are shown on Plate 9. The locations of wells within the planning region were also compiled as part of this project. Well locations are shown on Plate 10.

Residential water uses reported by the City of Albuquerque and self-supplied domestic uses were correlated with the single-family residential land-use category. The City of Albuquerque reports that approximately one-third of its commercial water-use is for apartment complexes. These water uses were assigned to the multi-family residential land-use category. The remaining portion of Albuquerque's commercial water uses and self-supplied commercial uses were correlated with the three commercial land-use types (major retail commercial, mixed and minor commercial, and office). Industrial water uses reported by the City of Albuquerque and self-supplied industrial water uses were correlated with the industrial and wholesale land-use category. Institutional water uses reported by Albuquerque were assigned to 7 land-use categories: (1) institutions, (2) schools and universities, (3) airports, (4) transportation and major utility corridors, (5) major public open space and parks (irrigated), (6) landfills and sewage treatment plants, and (7) other urban non-residential.

Three of the land-use categories were associated with no water uses. These are: (1) rangeland and dry agriculture, (2) urban vacant and abandoned, and (3) major open public space and parks (no water use). The withdrawal coefficients for these three land uses are equal to zero. The withdrawal coefficient for the natural drainage and riparian systems land-use category was calibrated to the total regional water withdrawals reported by Shomaker for both the open-water evaporation and riparian water-use categories. The withdrawal coefficient for Kirtland Air Force Base was based on water usage reported by Kirtland Air Force Base.

In preparing this report consideration was given to developing withdrawal coefficients to individual crop types. The Office of the State Engineer and the Middle Rio Grande Conservancy District have been collaborating on a project to map crops and vegetation within the Conservancy District using satellite imagery obtained in the summer of 2000. However, this information was not available at the time this report was prepared. Therefore, all irrigated agriculture is combined into one land-use category for the purpose of obtaining a regional withdrawal coefficient for irrigated agriculture.

There is conflicting information concerning total agricultural withdrawals. The Shomaker report discussed several different values for agricultural withdrawals, including values reported by the New Mexico Office of the State Engineer and the Middle Rio Grande Conservancy District. The values reported by the State Engineer are calculated values based on irrigated acreage, weather conditions, and calculated conveyance losses. The State Engineer calculates withdrawals of approximately 8 acre-feet per acre of irrigated land in the Conservancy District.

The Middle Rio Grande Conservancy District monitors total, or gross, diversions from the river at their major diversion locations. Gross diversions include operational diversions and unused water. The District also estimates return flows to the river, and calculates net diversions from the river as the difference between gross diversions and return flows to the river. The Conservancy District reports that its average net diversion is 350,000 acre-feet per year.

The District's total net diversions from the river are essentially the system water use of the District. The system water use includes agricultural evapotranspiration, ditchbank riparian evapotranspiration, aquifer recharge, and canal evaporation. Most of these terms are true depletions from the system; however, any aquifer recharge in excess of drainage back to the river would not be depletion from the system. A withdrawal coefficient for the irrigated lands of the Conservancy District based on the District's gross diversions and based on the State Engineer's estimates of irrigated acreage would be approximately 12 acre-feet per acre of irrigated land.

There is also conflicting information concerning the total number of acres of irrigated land. The Conservancy District reports that it has 50,541 acres of irrigated lands in Sandoval, Bernalillo, and Valencia counties. This number is considerably higher than the value reported by the State Engineer. It is also higher than the number of acres of irrigated agriculture shown on the Middle Rio Grande Council of Governments' existing land-use map. An explanation of the Conservancy District's estimates of irrigated acreage and water diversions are provided in Appendix B.

MRGCOG staff recognizes that the discrepancies in data concerning irrigation withdrawals and irrigated acres need to be resolved. However, in order to be consistent with the Shomaker report, this report relies on agricultural withdrawals as reported by the State Engineer for calculating agricultural withdrawal coefficients. This report relies on the area of irrigated agriculture obtained from MRGCOG's regional land-use map because this information is the most recent data available.

Table 6 shows the correlation between land-use categories and water-use categories for developing the initial withdrawal coefficients.

Table 6 – Correlation of land-uses categories and water-use categories

Land-Use Category	Associated Water-Use Categories
Single-family residential	Residential component of Albuquerque public water supply, and domestic self-supply
Multi-family residential	Apartment subcomponent of commercial component of Albuquerque public water supply
Major retail commercial	A portion of the commercial component of Albuquerque public water supply and a portion of self-supplied commercial
Mixed and minor commercial	A portion of commercial component of Albuquerque public water supply, and a portion of self-supplied commercial
Office	A portion of commercial component of public water supply, and a portion of self-supplied commercial
Industrial and wholesale	Industrial component of Albuquerque public water supply, and self-supplied industrial
Institutions	Portion of institutional component of Albuquerque public water supply
Schools and Universities	Portion of institutional component of Albuquerque public water supply
Airports	Portion of institutional component of Albuquerque public water supply
Transportation and major utility corridors	Portion of institutional component of Albuquerque public water supply
Irrigated agriculture	Irrigated agriculture diversions
Rangeland and dry agriculture	(no water use)
Major open space and parks (with water use)	Portion of institutional component of public water supply
Major open space and parks (no water use)	(no water use)
Natural drainage and riparian systems	Open-water evaporation and riparian consumptive use (from Shomaker report)
Urban vacant and abandoned	(no water use)
Landfills and sewage treatment plants	Portion of institutional component of public water supply
Other urban none-residential	Portion of institutional component of public water supply
Kirtland Air Force Base	Kirtland Air Force Base self supply

Withdrawal Coefficients

There was insufficient information available concerning water uses for the three categories of commercial land uses (major retail commercial, mixed and minor commercial, and office) to distinguish separate withdrawal coefficients for these land-use categories. Consequently, the withdrawal coefficients for these three land-use categories all have the same value. Similarly, there was insufficient information available on water uses for several of the other water uses that are collectively grouped as institutional water uses (institutions, schools and universities, airports, transportation and major utility corridors, landfills and sewage treatment plants, and other urban non-residential). The withdrawal coefficients for these institutional land-use categories were set equal to each other. The withdrawal coefficients for the initial test area (Albuquerque water service area) of the planning region are shown in Table 7.

Table 7 – Existing water withdrawals and withdrawal coefficients for the initial test area of the planning region

Land-Use Category	Area (acres)	Water Withdrawal (acre-feet)	Withdrawal coefficient (gal/acre/day)
Single-family residential	39,570	66,598	1,503
Multi-family residential	3,243	12,627	3,476
Major retail commercial	792	2,556	2,882
Mixed and minor commercial	6,220	20,082	2,882
Office	906	2,926	2,882
Industrial and wholesale	4,893	5,003	913
Institutions	632	710	1,003
Schools and universities	2,769	3,111	1,003
Airports	1,876	2,107	1,003
Transportation and major utility corridors	175	197	1,003
Irrigated agriculture	1,582	11,889	6,709
Rangeland and dry agriculture	983	0	0
Major open space and parks (with water use)	3,554	3,993	1,003
Major open space and parks (no water use)	759	0	0
Natural drainage and riparian systems	6,214	21,638	3,109
Urban vacant and abandoned	12,653	0	0
Landfills and sewage treatment plants	157	176	1,003
Other urban non-residential	1,071	1,204	1,003
Kirtland Air Force Base	224	22	87.25
Totals:	**88,273**	**154,839**	

The withdrawal coefficients derived from the initial test area were applied to the area calculations of the land-use categories on the existing land-use map for the entire region, resulting in a total water use for each land-use category. The total regional water withdrawals summed to 677,639 acre-feet per year.

Shomaker reported total regional withdrawals for 1995 to be 600,000 acre-feet per year. By comparison the total of regional withdrawals using the land-use approach and initial withdrawal coefficients was 13 percent higher than the value reported by Shomaker. However, since the land-use approach in this report uses the same total withdrawal values for irrigated agriculture, open-water evaporation, and riparian consumption as used in the Shomaker report, the difference between the methods is due to a difference in the amount associated with public water supply and the sum of the self-supplied water-use categories (e.g. self-supplied commercial, self-supplied industrial, self-supplied domestic, self-supplied power, self-supplied mining, self-supplied livestock). The largest share of these water withdrawals (89%) is in the category of public water supply.

Some of the difference in the results between the regional withdrawals reported by Shomaker and the results using the initial withdrawal coefficients may be due to incomplete availability of water-use information for the region as a whole. Some of the difference may also be due to the time difference from 1995 to 2000. However, it seems unlikely that the 5-year period of time would have caused a 13 percent increase in total regional withdrawals, especially considering that the Shomaker report documented a trend of declining total regional withdrawals for public water supply from 1995 to 2000.

Considering the information presented above, the total regional water withdrawals obtained using the withdrawal coefficients derived from the initial test area were considered to be too high, especially for making regional projections of future water withdrawals. Consequently, the withdrawal coefficients were adjusted downward to obtain a total regional water use calibrated to the total regional water use in the Shomaker report. Water withdrawals for 13 of the land-use categories (single-family residential, multi-family residential, major retail commercial, mixed and minor commercial, office, industrial and wholesale, institutions, schools and universities, airports, transportation and major utility corridors, major public open space and parks with water use, landfills and sewage treatment plants, and other urban non-residential) were uniformly adjusted downward to match the total regional withdrawals for the corresponding water-use categories reported by Shomaker. The adjusted water withdrawals for each of the land-use categories were then used to derive adjusted withdrawal coefficients. The adjusted regional water withdrawals and withdrawal coefficients are shown in Table 8.

Table 8 – Existing water withdrawals and withdrawal coefficients for the planning region

Land-Use Category	Area (acres)	Water Withdrawal (acre-feet)	Withdrawal coefficient (gal/acre/day)
Single-family residential	94,500	108,557	1,026
Multi-family residential	3,763	10,000	2,372
Major retail commercial	1,112	2,451	1,967
Mixed and minor commercial	8,689	19,149	1,967
Office	927	2,042	1,967
Industrial and wholesale	8,403	5,865	623
Institutions	2,089	1,602	685
Schools and universities	4,002	3,069	685
Airports	6,681	5,123	685
Transportation and major utility corridors	770	591	685
Irrigated agriculture	37,516	281,934	6,709
Rangeland and dry agriculture	2,646,307	0	0
Major open space and parks (with water use)	6,521	5,001	685
Major open space and parks (no water use)	550,331	0	0
Natural drainage and riparian systems	42,541	148,140	3,109
Urban vacant and abandoned	40,792	0	0
Landfills and sewage treatment plants	2,779	2,131	685
Other urban non-residential	1,756	1,347	685
Kirtland Air Force Base	30,695	3,000	87.25
Totals:	**3,490,174**	**600,002**	

Projections for Regional Water Withdrawals

Base-Case Projection of Future Water Withdrawals

The withdrawal coefficients, adjusted to calibrate total regional water withdrawals with the Shomaker report, were used with the future land-use map to calculate the base-case projection of future water withdrawals. The results for the planning region are shown in Table 9. Total future water withdrawals for the region in the base-case projection do not increase by as much as might be expected due to the trend of converting agricultural lands to other land uses. The base-case projection envisions a decrease of 8,796 acres for irrigated agriculture. The amount of total withdrawals for the region increases by approximately 20 percent in the base-case projection compared to the existing total regional withdrawals.

Table 9 – Future land-use areas and water withdrawals
Planning Region

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	227,824	261,714
Multi-family residential	6,302	16,747
Major retail commercial	1,492	3,289
Mixed and minor commercial	16,452	36,257
Office	2,685	5,917
Industrial and wholesale	12,286	8,574
Institutions	2,555	1,959
Schools and universities	3,526	2,704
Airports	5,476	4,200
Transportation and major utility corridors	659	505
Irrigated agriculture	28,720	215,833
Rangeland and dry agriculture	2,526,313	0
Major open space and parks (with water use)	5,434	4,167
Major open space and parks (no water use)	549,766	0
Natural drainage and riparian systems	42,613	148,391
Urban vacant and abandoned	20,209	0
Landfills and sewage treatment plants	2,954	2,265
Other urban non-residential	3,602	2,762
Kirtland Air Force Base	30,777	3,008
Totals:	3,489,645	718,292

The withdrawal coefficients for selected land-use categories as discussed above can be converted into units of gallons per person per day, a unit that is often used to express urban and suburban water use. If the term “urban/suburban withdrawals” is defined to include withdrawals for all land-use categories excluding the irrigated agriculture land-use category and the natural drainage and riparian systems land-use category, then the term “regional urban/suburban withdrawal rate” can be defined using the withdrawals for the remaining land-use categories (the “urban/suburban” land-use categories) and the projected future population. The term “urban/suburban withdrawals” as it is used in this context includes all water withdrawn by people for personal, commercial, and industrial uses, but excludes withdrawals for agriculture. As such, the term would include water withdrawals in urban, suburban, and rural community portions of the planning region.

Using the definitions above, the total existing “urban/suburban withdrawals” are approximately 170 thousand acre-feet per year. The year 2000 Census population is 712,738. These numbers can be combined to yield a regional urban/suburban withdrawal rate equal to approximately 212 gallons per person per day. Similarly, for the base-case projection the corresponding regional urban/suburban withdrawal would be approximately 354 thousand acre-feet per year associated with a projected population of 1.49 million (i.e., the projected population used to develop the trend land-use map for the future). The corresponding regional urban/suburban withdrawal rate for the base-case projection is also 212 gallons per person per day.

The base-case projection results disaggregated by county are shown in Tables 10, 11, and 12. The base-case projection results disaggregated by planning subregion are shown in tables 13, 14, and 15. The values for both acreages and withdrawals in Tables 10 through 15 were rounded to zero decimal places, so the subtotals and totals in these tables may be slightly different than shown in Table 9.

Table 10 – Future land-use areas and water withdrawals Bernalillo County

Land-Use Category		Area (acres)	Withdrawal (acre-feet)
Single-family residential		94,020	107,992
Multi-family residential		3,913	10,397
Major retail commercial		1,295	2,853
Mixed and minor commercial		11,552	25,454
Office		2,153	4,744
Industrial and wholesale		9,342	6,519
Institutions		1,867	1,432
Schools and universities		2,887	2,214
Airports		5,351	4,103
Transportation and major utility corridors		160	123
Irrigated agriculture		4,502	33,828
Rangeland and dry agriculture		371,543	0
Major open space and parks (with water use)		4,469	3,427
Major open space and parks (no water use)		88,594	0
Natural drainage and riparian systems		11,824	41,170
Urban vacant and abandoned		14,544	0
Landfills and sewage treatment plants		2,150	1,648
Other urban non-residential		2,499	1,916
Kirtland Air Force Base		30,777	3,008
	Totals:	**663,442**	**250,828**

Table 11 – Future land-use areas and water withdrawals Sandoval County

Land-Use Category		Area (acres)	Withdrawal (acre-feet)
Single-family residential		87,818	100,868
Multi-family residential		1,504	3,996
Major retail commercial		186	410
Mixed and minor commercial		2,663	5,868
Office		153	337
Industrial and wholesale		1,802	1,257
Institutions		331	254
Schools and universities		338	259
Airports		37	28
Transportation and major utility corridors		287	220
Irrigated agriculture		7,478	56,190
Rangeland and dry agriculture		1,558,476	0
Major open space and parks (with water use)		621	476
Major open space and parks (no water use)		423,076	0
Natural drainage and riparian systems		20,072	69,888
Urban vacant and abandoned		5,141	0
Landfills and sewage treatment plants		82	63
Other urban non-residential		592	454
Kirtland Air Force Base		0	0
	Totals:	**2,110,657**	**240,568**

Table 12 – Future land-use areas and water withdrawals
Valencia County

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	45,986	52,820
Multi-family residential	886	2,354
Major retail commercial	11	24
Mixed and minor commercial	2,238	4,931
Office	379	835
Industrial and wholesale	1,142	797
Institutions	356	273
Schools and universities	301	231
Airports	88	67
Transportation and major utility corridors	212	163
Irrigated agriculture	16,740	125,786
Rangeland and dry agriculture	577,953	0
Major open space and parks (with water use)	344	264
Major open space and parks (no water use)	16,062	0
Natural drainage and riparian systems	10,717	37,315
Urban vacant and abandoned	525	0
Landfills and sewage treatment plants	722	554
Other urban non-residential	511	392
Kirtland Air Force Base	0	0
Totals:	**675,173**	**226,806**

Table 13 – Future land-use areas and water withdrawals
Rio Grande Valley subregion

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	220,553	253,329
Multi-family residential	6,302	16,744
Major retail commercial	1,492	3,288
Mixed and minor commercial	15,890	35,013
Office	2,564	5,650
Industrial and wholesale	12,110	8,450
Institutions	2,438	1,869
Schools and universities	3,472	2,662
Airports	5,439	4,170
Transportation and major utility corridors	651	499
Irrigated agriculture	27,675	207,952
Rangeland and dry agriculture	824,022	0
Major open space and parks (with water use)	5,434	4,166
Major open space and parks (no water use)	272,303	0
Natural drainage and riparian systems	35,521	123,679
Urban vacant and abandoned	20,080	0
Landfills and sewage treatment plants	1,553	1,191
Other urban non-residential	3,283	2,517
Kirtland Air Force Base	30,777	3,008
Totals:	**1,491,559**	**674,187**

Table 14 – Future land-use areas and water withdrawals
Rio Jemez Subregion

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	4,263	4,897
Multi-family residential	0	0
Major retail commercial	0	0
Mixed and minor commercial	187	412
Office	30	66
Industrial and wholesale	86	60
Institutions	117	90
Schools and universities	7	5
Airports	0	0
Transportation and major utility corridors	8	6
Irrigated agriculture	491	3,689
Rangeland and dry agriculture	428,923	0
Major open space and parks (with water use)	0	0
Major open space and parks (no water use)	207,838	0
Natural drainage and riparian systems	6,965	24,251
Urban vacant and abandoned	92	0
Landfills and sewage treatment plants	6	5
Other urban non-residential	78	60
Kirtland Air Force Base	0	0
Totals:	**649,091**	**33,541**

Table 15 – Future land-use areas and water withdrawals
Rio Puerco Subregion

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	3,008	3,455
Multi-family residential	0	0
Major retail commercial	0	0
Mixed and minor commercial	376	829
Office	91	201
Industrial and wholesale	89	62
Institutions	0	0
Schools and universities	46	35
Airports	37	28
Transportation and major utility corridors	0	0
Irrigated agriculture	554	4,163
Rangeland and dry agriculture	1,273,367	0
Major open space and parks (with water use)	0	0
Major open space and parks (no water use)	69,625	0
Natural drainage and riparian systems	126	439
Urban vacant and abandoned	36	0
Landfills and sewage treatment plants	1,395	1,070
Other urban non-residential	241	185
Kirtland Air Force Base	0	0
Totals:	**1,348,991**	**10,467**

10-year Interval Projections of Water Withdrawals

Appendix A contains tables showing the population projections for New Mexico State Planning and Development District 3 which includes the three counties of the Middle Rio Grande Water Planning Region. The REMI model discussed in Appendix A does not generate a steady rate of population growth into the future. Instead, the rate of population growth is projected to slow over the next 50 years. The series A projections shown in Appendix A provide a total regional population for the year 2050 that is only 1% lower than the Focus 2050 population projection that was used to forecast the trend land-use patterns. Ten-year interval projections in this report are based on the series-A projections in Appendix A in order to be reasonably consistent with preceding land-use analysis (based on the Focus 2050 population projections). The projected regional population is shown in Figure 5.

Withdrawals for each of the land-use categories were calculated based on the relative amount of population growth at each 10-year interval from the year 2000 to the year 2050. The series-A projection estimates that approximately 25 percent of the total population change from the year 2000 to the year 2050 will occur by the year 2010. Thus, approximately 25 percent of the increase in withdrawals for each land-use category, or decrease for irrigated agriculture, is projected to occur by the year 2010. Withdrawals based on the series-A population projections and the base-case projections of withdrawals for the year 2050 are shown in Table 19.

Figure 5 – Projected Population Growth in the Planning Region
Population projections are based on the Series-A projections in Appendix A

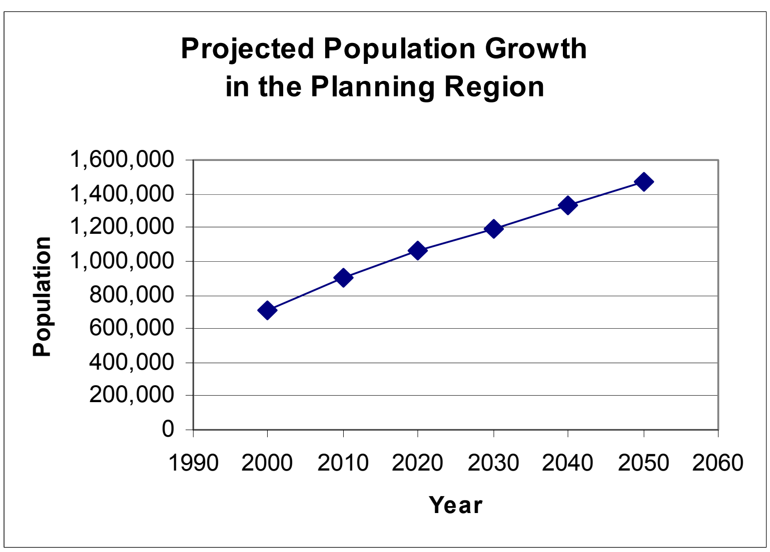

Table 16 – Projected withdrawals at 10-year intervals
Planning Region

Land-Use Category	Withdrawals (acre-feet)					
	2000	2010	2020	2030	2040	2050
Single-family residential	108,557	146,451	179,297	205,803	232,265	261,680
Multi-family residential	10,000	11,670	13,117	14,285	15,451	16,747
Major retail commercial	2,451	2,658	2,837	2,982	3,126	3,287
Mixed and minor commercial	19,149	23,382	27,051	30,012	32,967	36,253
Office	2,042	3,001	3,832	4,502	5,172	5,916
Industrial and wholesale	5,865	6,535	7,116	7,585	8,053	8,573
Institutions	1,602	1,690	1,767	1,829	1,890	1,959
Schools and universities	3,069	2,979	2,900	2,837	2,774	2,704
Airports	5,123	4,894	4,696	4,536	4,376	4,198
Transportation and major utility corridors	591	570	552	537	522	506
Irrigated agriculture	281,934	265,568	251,383	239,936	228,508	215,804
Rangeland and dry agriculture	0	0	0	0	0	0
Major open space and parks (with water use)	5,001	4,795	4,616	4,471	4,327	4,167
Major open space and parks (no water use)	0	0	0	0	0	0
Natural drainage and riparian systems	148,140	148,198	148,248	148,288	148,328	148,373
Urban vacant and abandoned	0	0	0	0	0	0
Landfills and sewage treatment plants	2,131	2,164	2,193	2,216	2,239	2,265
Other urban non-residential	1,347	1,697	2,001	2,246	2,490	2,762
Kirtland Air Force Base	3,000	3,002	3,004	3,005	3,006	3,008
Totals:	**600,002**	**629,254**	**654,608**	**675,069**	**695,496**	**718,202**

Depletions and Depletion Coefficients

Depletions represent that portion of a withdrawal that is evaporated, transpired, incorporated into crops or products, consumed by people or livestock, or otherwise removed from the regional water environment. In the simplest type of water budget, depletions are equal to withdrawals minus return flows. Although most types of withdrawals from surface water and ground water are relatively easy to measure, depletions are often difficult if not impossible to measure. Fortunately, many types of return flows can be measured or estimated, and therefore depletions can be calculated. As an example, a municipal utility that operates both a water and wastewater utility can compare total billed water amounts to total measured flows through their wastewater treatment plant, and then calculate the percent return flow for its system as a whole.

Wastewater is not typically measured on an account-by-account basis as is the case for water. This makes it somewhat difficult to characterize return flows for different categories of water uses, and even more difficult to characterize return flows for regional land-use categories. Nevertheless, depletion coefficients are derived for this report based on available information about typical rates of wastewater generation and on regional demographic information. The dimensions for the depletion coefficients are the same as for the withdrawal coefficients (length/time), and the unit of measurement used in this report is gallons per acre per day. This report assumes that the total existing depletions for the region are as reported in the Shomaker report (340,000 acre-feet per year). Depletion coefficients developed for this report were adjusted so that total existing regional depletions are identical to the regional depletions in the Shomaker report.

Depletions for Residential Land Uses

Hammer and Hammer (2001) provide estimates of approximate wastewater flows in gallons per person per day for a number of different water uses, including residential water uses. They report that typical single-family houses generate 80 gallons of wastewater per person per day. Hammer and Hammer also report that larger houses generate as much as 120 gallons per person per day, and that apartments typically generate 60 to 75 gallons of wastewater per person per day.

If we use the number typical for single-family residential homes as the regional average for household wastewater generation and combine it with the current population of the region (712,738), we might expect a total regional residential wastewater generation of approximately 57 million gallons per day (or 63.9 million acre-feet per year). This number is approximately 54 percent of the total existing residential water withdrawal as calculated from the land-use model.

Not all of the wastewater generated from residential land uses is likely to be return flow to the basin. Some wastewater may be consumed for irrigation or may be lost as evaporation in percolation ponds. Thus, assuming the calculated amount of wastewater generated is approximately correct, we might expect that depletions for regional residential land uses to be 46 percent, or greater, of regional residential land-use withdrawals. The depletion coefficient that would be calculated for all residential land uses (both single-family residential and multi-family residential) based on the projected depletions calculated above, and the area of existing residential land uses, is 497 gallons per acre per day.

The depletion coefficient derived above is for all residential land uses, and therefore, it includes both the single-family residential land-use category and the multi-family land-use category. Individual depletion coefficients for each of these land-use categories can be calculated from the number of persons living in each of the residential land-use categories and the appropriate rate for wastewater generation for each type. These numbers would represent the return-flow rates. The depletion rates can then be calculated by subtracting return-flow rates from withdrawal rates. The depletion coefficient can be obtained by dividing the depletion rate by the number of acres for the particular land-use category. This approach assumes that withdrawals minus return flows are equal to depletions. This is not always the case at the scale of a single utility, even a large utility, as was noted above. However, it is a reasonable estimate when viewed on a regional scale.

The number of persons living in each of the residential land-use categories can be calculated from the number the total dwelling units in each category and the average regional household size for each type of residence. The most recent data from the Middle Rio Grande Council of Governments indicates that there are 226,115 single-family dwelling units and 68,084 multi-family dwelling units in the region. The Middle Rio Grande Council of Governments estimates that the current average household size for single-family dwelling units is 2.7 persons per dwelling unit and the average household size for multi-family dwelling units is 1.3 persons per dwelling unit.

Using the average household density data, there should be approximately 610,511 people living in single-family residence and 88,509 people living in multi-family residences. The sum of these two numbers is 699,020. This is approximately 2 percent less than the current population obtained from the U.S. Census Bureau for the year 2000. This error is probably less than the uncertainty in the other parameters used to derive the depletion coefficients.

As previously noted, Hammer and Hammer cite a wastewater generation rate of 80 gallons per person per day for typical single-family residences. They cite a range of 60 to 75 gallons per person per day for multi-family residences (apartments). The arithmetic mean value of this range for multi-family residences is approximately 68 gallons per person per day. Combining these rates with the respective populations, the regional rates of wastewater generation would be 48.8 million gallons per day (54,709 acre-feet per year) for single-family land uses, and 6.02 million gallons per day (6,742 acre-feet per year) for multi-family residential land uses.

If the rates of wastewater generation for each residential land-use category are subtracted from the withdrawal rates for each land-use category, the differences should approximately represent the depletions for each land-use category. The regional withdrawal rate for the single-family residential land-use category was previously estimated to be 108,557 acre-feet per year. The regional withdrawal rate for the multi-family residential land-use category was previously estimated to be 10,000 acre-feet per year. Thus, the depletions should be 53,484 acre-feet per year and 3,258 acre-feet per year for single-family and multi-family residences, respectively. After converting units and combining with the areas for each of the land-use types, the depletion coefficients are calculated to be 508 gallons per acre per day for the single-family residential land-use category and 773 gallons per acre per day for the multi-family residential land-use type.

The assumption that all of the wastewater generated from residences becomes return flow is probably not accurate, even at the regional scale. At least some wastewater is probably lost in evaporation and transpiration. Thus, the true values of the two residential depletion coefficients would be somewhat higher than the values calculated above. However, in lieu of more detailed information concerning regional-scale depletions for residential land uses, the true values of these parameters can only be estimated. For purposes of this report, the values of the depletion coefficients for the single-family and multi-family residential land-use categories were adjusted upwards by

10 percent each. Thus, the depletion coefficients for the single-family and multi-family residential land-use categories used in this report are estimated to be approximately 559 and 850 gallons per acre per day, respectively.

Depletions for Irrigated Agriculture

Agricultural depletions for this report are defined to be the same as the agricultural depletions listed in the Shomaker report. Shomaker reported agricultural depletions of approximately 93,600 acre-feet per year for the planning region. Regional agricultural return flows would be approximately 188 thousand acre-feet per year based on the withdrawals and depletions reported by Shomaker. The depletion coefficient for irrigated agriculture based on this level of depletion and the existing regional area for irrigated agriculture is 2,227 gallons per acre per day. This value is equivalent to 2.49 feet per year.

Depletions for Natural Drainage and Riparian Systems

The withdrawal coefficient for the natural drainage and riparian systems land-use category was calibrated to the sum of the withdrawals reported by Shomaker for the open-water evaporation and riparian water-use categories. Since all of the withdrawals for these two water-use categories are depletions, the depletion coefficient for the natural drainage and riparian land-use category is the same as the withdrawal coefficient (3,109 gallons per acre per day). This value is equivalent to 3.48 feet per year.

Calibrating Depletion Coefficients on a Regional Scale

Depletion coefficients for existing land-use categories were calibrated to adjust total calculated regional depletions to be the same as reported in the Shomaker report. This was done by initially setting the depletions for the irrigated agriculture land-use category and the natural drainage and riparian systems land-use categories to the values as discussed above. Depletion coefficients for these two land-use categories were then calculated by dividing the depletions by the areas for each of these land-use categories. The depletion coefficients for the single-family and multi-family residential land-use categories were set to the values discussed above (559 and 850 gallons per acre per day, respectively), and the depletions for these two land-use categories were calculated. The total depletions for these four land-use categories sums to 304,457 acre-feet per year. This is approximately 90 percent of the total regional depletions reported by Shomaker.

Information about depletions for the remaining 15 land-use categories is sparse. However, since the total depletions for these 15 land-use categories represent only 10 percent of total regional depletions, the depletion coefficients for these 15 land-use categories were derived by using a multiplier to uniformly scale down the values of their respective withdrawal coefficients until total regional depletions matched total regional depletions reported by Shomaker. The multiplier needed to achieve this match was 0.692. The depletion coefficients and depletions for the existing land-use map that were derived from this approach are shown in Table 20. The projected future depletions for the base-case projection using the same depletion coefficients and the areas for each of the future land-use categories are shown in Table 21.

Table 17 – Existing depletions and depletion coefficients
Planning Region

Land-Use Category	Depletions (acre-feet)	Depletion coefficient (gal/acre/day)
Single-family residential	59,164	559
Multi-family residential	3,582	850
Major retail commercial	1,696	1,361
Mixed and minor commercial	13,249	1,361
Office	1,413	1,361
Industrial and wholesale	4,058	431
Institutions	1,108	474
Schools and universities	2,124	474
Airports	3,545	474
Transportation and major utility corridors	409	474
Irrigated agriculture	93,590	2,227
Rangeland and dry agriculture	0	0
Major open space and parks (with water use)	3,460	474
Major open space and parks (no water use)	0	0
Natural drainage and riparian systems	148,121	3,109
Urban vacant and abandoned	0	0
Landfills and sewage treatment plants	1,475	474
Other urban non-residential	932	474
Kirtland Air Force Base	2,076	60
Totals:	**340,002**	

Table 18 – Future depletions in the planning region for the base-case projection

Land-Use Category	Depletions (acre-feet)
Single-family residential	142,636
Multi-family residential	6,000
Major retail commercial	2,276
Mixed and minor commercial	25,087
Office	4,094
Industrial and wholesale	5,933
Institutions	1,355
Schools and universities	1,871
Airports	2,906
Transportation and major utility corridors	350
Irrigated agriculture	71,647
Rangeland and dry agriculture	0
Major open space and parks (with water use)	2,883
Major open space and parks (no water use)	0
Natural drainage and riparian systems	148,372
Urban vacant and abandoned	0
Landfills and sewage treatment plants	1,567
Other urban non-residential	1,911
Kirtland Air Force Base	2,081
Totals:	**420,969**

Comments on Withdrawal and Depletion Coefficients

The water withdrawal and depletion coefficients derived for this report are based on regional-scale averages for withdrawals and depletions. There are certainly many variations in water-management practices and hydrogeology throughout the region, and these variations would cause significant variations of both types of coefficients at the local scale. Because of this, the values of these regional coefficients have less meaning if used at smaller scales, and they probably lose most of their meaning if they are used at the scale of individual utilities or individual irrigated parcels of land.

Agricultural withdrawals are the largest single component in the water budget for our region. They become especially dominant when we consider gross diversions rather than net diversions. The continuing discrepancies in information related to existing agricultural withdrawals and depletions, and the remaining uncertainties related to the existing number of acres of irrigated agriculture warrant caution in using or comparing the various projections for agricultural withdrawals and depletions derived in this report. Resolution of these uncertainties would lead to greater accuracy in estimating both existing and future agricultural withdrawals and depletions.

Another area warranting caution concerning the land-use approach is the simplified treatment of agricultural withdrawals and depletions. This simplified approach does not take into consideration all of the components of flow that actually occur as agricultural water is managed today. For example, retirement of agricultural acreage, or converting it to other land uses, could mean elimination of irrigation canals. This would lead to reductions in groundwater recharge that would partially offset gains derived from the retirement or conversion of the irrigated lands.

Depletion coefficients for land-use categories are less constrained than the withdrawal coefficients, primarily because of the sparser data for measured depletions and return flows. The projected depletions calculated for this report are considered to be less reliable than the projected withdrawals, especially projected depletions for individual land-use categories. For this reason, projected depletions are not calculated for the variations from the base-case projection that are discussed in Appendix C. For the same reason, depletion projections disaggregated by subregion and by county are not presented.

The regional land-use methods used in this report are adequate to provide reasonable estimates of future regional withdrawals and depletions. However, these methods are not recommended for more detailed water-budget evaluations, nor are they recommended for comparing the hydrologic impacts of planning alternatives. Detailed evaluations of water budgets should generally utilize more sophisticated hydrologic tools, including, in some cases, hydrologic models. Hydrologic models that can simulate the interaction between surface water and ground water would be particularly useful for evaluating many types of planning alternatives at a regional scale.

The generic groundwater model developed by the United States Geological Survey, commonly known as Modflow, could be used for more detailed analyses of the water budgets associated with various planning alternatives. A regional-scale model of the Middle Rio Grande Groundwater Basin has already been developed by the U.S. Geological Survey, and updated by the New Mexico State Engineer's Office. This model could potentially be adapted for evaluating planning alternatives. Another potential model that can simulate the interaction of surface water and ground water is the MIKE SHE modeling system prepared by DHI Water & Environment.

Summary and Conclusions

A base-case projection and several variations of the base-case projection were prepared to forecast a range of future water needs in the planning region. The term “base case” as it is used in this report is essentially an assessment of the magnitude of our region’s water supply needs in the future assuming that recent trends in the growth were to continue into the future, and assuming that sufficient water supplies will be available to meet those demands. Future water needs in this report were characterized as both projected withdrawals and depletions. These projections were partially based on information contained in the report entitled “Historical and Current Water Use in the Middle Rio Grande Region” prepared by John Shomaker and Associates and PioneerWest. The withdrawal and depletion projections were also based on a forecasted future land-use map prepared by the Middle Rio Grande Council of Governments for the Focus 2050 project. This future land-use map reflects the continuation of existing growth trends and a projected regional population in the year 2050 of approximately 1.47 million people.

Shomaker et al. reported that 1995 regional withdrawals were approximately 600,000 acre-feet per year, and that 1995 regional depletions were approximately 340,000 acre-feet per year. Withdrawal and depletion coefficients relating water use to land uses were adjusted so that calculated existing regional water withdrawals and depletions based on the land-use map prepared by the Middle Rio Grande Council of Governments matched the regional withdrawals and depletions reported by Shomaker.

The base-case projection assumed a continuation of urban growth in the region and a continuation of the trend of decreasing irrigated agricultural acreage. The base-case projection yielded a forecast of approximately 718 thousand acre-feet per year for regional withdrawals.

Depletion coefficients were prepared to calculate projected depletions for the base-case projection. Depletions for the irrigated agriculture land-use category were set equal to the value reported by Shomaker et al. Depletions for the natural drainage and riparian systems land-use category were set equal to the sum of the depletions reported by Shomaker et al. for the riparian vegetation and open water evaporation water-use categories. Depletions for the single-family and multi-family residential land-use categories were calculated using typical rates of wastewater generation for single-family and multi-family residences and local demographic information. The depletion coefficients for the remaining land-use categories were derived by uniformly reducing the withdrawal coefficients by the same factor until calculated regional depletions matched the regional depletions reported by Shomaker et al. The total calculated regional depletion associated with the base-case withdrawals was approximately 420 thousand acre-feet per year.

Glossary

Demand management: Water management programs that reduce the demand for water, such as water conservation and drought measures including drought rationing, rate incentive programs, public awareness and education, drought landscaping, etc.

Demography: The statistical science dealing with the distribution, density, vital statistics, and other related characteristics of population.

Demographics: Relating to the statistical study of human populations to include such characteristics and factors as population counts, births, deaths, migration, sex, age, and related statistics.

Depletion: That part of a withdrawal that has been evaporated, transpired, or incorporated into crops or products, consumed by people or livestock, or otherwise removed from the water environment. It includes the portion of ground-water recharge resulting from seepage or deep percolation (in connection with a water use) that is not economically recoverable in a reasonable number of years, or is not usable. Same as consumptive use. Note: this definition follows the definition used by the NMOSE and the ISC.

Depletion Coefficient: A number that relates the rate of water depletions to the unit area of a land-use map unit. Dimensionally, the coefficient has units of length * time^{-1}. The units used in this report are expressed as gallons per acre per day.

Diversion: The removal of water from either a surface-water or groundwater system. For the purposes of this report, the term diversion is the same as a withdrawal. Sometimes gross diversions are distinguished from net diversions. In this case, a withdrawal is generally the same as a gross diversion.

Water Budget: A summary that shows the balance in a hydrologic system between water supplies (inflow) to the system and water losses (outflow) from the system. It is a common reporting tool for water-resource systems.

Withdrawal: Water that is either diverted from the surface-water system or pumped from wells. Some of this water may return to either the surface- or ground-water system.

Withdrawal coefficient: A number that relates the rate of water withdrawals to the unit area of a land-use map unit. Dimensionally, the coefficient has units of length * time^{-1}. The units used in this report are expressed as gallons per acre per day. Similar units, such as feet per year, are often used to express the water requirements for irrigated agriculture.

Xeriscape: Water efficient landscaping appropriate to the natural environment.

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Plates

Appendices

Appendix A	Population Projections to 2050 for State Planning and Development District 3
Appendix B	Information on diversions and irrigated agriculture provided by the Middle Rio Grande Conservancy District
Appendix C	Potential variations from the base-case projection

Appendix A

Population projections to 2050
for the Middle Rio Grande Water Planning Region

Appendix B

Information on diversions and irrigated agriculture provided by the Middle Rio Grande Conservancy District

Appendix C

Potential variations from the base-case projection

Variations of the Base-Case Projection for Future Withdrawals

Variation 1 - No Loss of Irrigated Agriculture

The Focus 2050 plan recommended that urban development stop encroaching on irrigated agriculture in order to help preserve agriculture in the region. Preservation of agriculture is a theme that has also been heard in comments received from the public in the regional water planning process. A variation of the base-case projection of future withdrawals was developed using the assumption that there would be no decrease in irrigated agriculture. For this variation, the same total acreage of future developed lands is assumed; however, irrigated agriculture is assumed to remain constant at approximately 37 thousand acres, and the development that would have occurred on irrigated lands is assumed to occur on lands classified as urban vacant and abandoned. This variation is presented mainly to compare total regional withdrawals to total regional withdrawals for the base-case projection. For this reason, the projected withdrawals are not disaggregated by county or by planning subregion.

Total regional withdrawals for this variation are approximately 784 thousand acre-feet per year. This represents an increase of 31 percent over the total current regional withdrawals, and an increase of 9 percent compared to the base-case projection. Total projected urban withdrawals (as the term was defined previously) are identical to the base-case projection, approximately 354 thousand acre-feet per year, and the associated projected population is 1.49 million. Because neither of these two numbers is different from the base-case projection, the corresponding regional urban withdrawal rate is still 212 gallons per person per day. The results for this projection are shown in Table 16.

Table C-1 – Future land-use areas and water withdrawals in the planning region for the variation-1 projection

Land-Use Category	Area (acres)	Withdrawal (acre-feet)
Single-family residential	227,824	261,680
Multi-family residential	6,303	16,747
Major retail commercial	1,492	3,288
Mixed and minor commercial	16,453	36,254
Office	2,685	5,916
Industrial and wholesale	12,286	8,573
Institutions	2,554	1,958
Schools and universities	3,526	2,704

Airports	5,476	4,199
Transportation and major utility corridors	659	505
Irrigated agriculture	37,516	281,898
Rangeland and dry agriculture	2,526,314	0
Major open space and parks (with water use)	5,434	4,166
Major open space and parks (no water use)	549,766	0
Natural drainage and riparian systems	42,613	148,373
Urban vacant and abandoned	11,414	0
Landfills and sewage treatment plants	2,954	2,265
Other urban non-residential	3,602	2,762
Kirtland Air Force Base	30,777	3,008
Totals:	**3,489,648**	**784,296**

Variation 2 - Additional Urban and Suburban Water Conservation

The base-case projection for future water withdrawals and the variation-1 projections (no loss of irrigated agriculture) assume no increase in water conservation compared to current water-use practices. Given the current scarcity of water in the region, the likelihood that marginal water supplies will be significantly more expensive, and the momentum that is already in place for urban and suburban water conservation, it seems unlikely that rates of water use will remain as they are today. Therefore, it seems reasonable to examine a variation of the base-case projection incorporating some level of additional water conservation.

Variation 2 was developed using these assumptions: (1) that there would be a 15 percent reduction in the rates of water use for all land-use categories except for: (a) irrigated agriculture and (b) natural drainage and riparian systems; and (2) the same acreages for all of the land-use categories as in the base-case projection. Variation 2 is also presented to compare total regional withdrawals to total regional withdrawals for the base-case projection. Therefore, the projections are not disaggregated by county or by planning subregion.

Total regional withdrawals for variation 2 are approximately 665 thousand acre-feet per year. This represents an increase of 11 percent over the total current regional withdrawals, and a decrease of 7 percent compared to the base-case projection. Total projected urban withdrawals (as the term was defined previously) are reduced to approximately 301 thousand acre-feet per year associated with the same target population of 1.49 million. The corresponding regional urban withdrawal rate is reduced to 180 gallons per person per day. The results for variation 2 are shown in Table 17.

Table C-2 - Future land-use areas, water withdrawals, and withdrawal coefficients in the planning region for the variation-2 projection

Land-Use Category	Area (acres)	Water Withdrawal (acre-feet)	Withdrawal coefficient (gal/acre/day)
Single-family residential	227,824	222,428	872
Multi-family residential	6,303	14,235	2,016
Major retail commercial	1,492	2,794	1,672
Mixed and minor commercial	16,453	30,816	1,672
Office	2,685	5,029	1,672
Industrial and wholesale	12,286	7,287	530
Institutions	2,554	1,665	582
Schools and universities	3,526	2,298	582
Airports	5,476	3,569	582
Transportation and major utility corridors	659	429	582
Irrigated agriculture	28,720	215,804	6,709
Rangeland and dry agriculture	2,526,314	0	0
Major open space and parks (with water use)	5,434	3,541	582
Major open space and parks (no water use)	549,766	0	0
Natural drainage and riparian systems	42,613	148,373	3,109
Urban vacant and abandoned	20,210	0	0
Landfills and sewage treatment plants	2,954	1,925	582
Other urban non-residential	3,602	2,348	582
Kirtland Air Force Base	30,777	2,556	74
Totals:	**3,489,648**	**665,097**	

<u>Variation 3 - No Increase in Regional Withdrawals</u>

This variation is presented to look at the level of urban and suburban water conservation that would be necessary to stabilize total regional water withdrawals at the existing level assuming: (1) the same areas for all land uses as in the base-case projection, and (2) the same withdrawal coefficients for both the irrigated agriculture and natural drainage and riparian land-use categories as in the base-case projection. This variation is similar to variation 2 (additional urban and suburban water conservation) except that the withdrawal coefficients were uniformly reduced for the urban land-use categories so that the total projected regional withdrawals were reduced to the same level as the total existing regional withdrawals. Variation 3 is also presented to compare total regional withdrawals to total regional withdrawals for the base-case projection, and so the projections are not disaggregated by county or by planning subregion.

Withdrawal coefficients for urban land uses were decreased by one third in order to stabilize total regional withdrawals at the existing level of 600,000 acre-feet per year. Total projected urban withdrawals (as the term was defined previously) are reduced to approximately 236 thousand acre-feet per year associated with the same projected population of 1.49 million. The corresponding regional urban withdrawal rate is reduced to 141 gallons per person per day. The results for variation 3 are shown in Table 18.

Table C-3 - Future land-use areas, water withdrawals, and withdrawal coefficients in the planning region for the variation-3 projection

Land-Use Category	Area (acres)	Water Withdrawal (acre-feet)	Withdrawal coefficient (gal/acre/day)
Single-family residential	227,824	174,279	683
Multi-family residential	6,303	11,153	1,580
Major retail commercial	1,492	2,190	1,310
Mixed and minor commercial	16,453	24,145	1,310
Office	2,685	3,940	1,310
Industrial and wholesale	12,286	5,710	415
Institutions	2,554	1,304	456
Schools and universities	3,526	1,801	456
Airports	5,476	2,796	456
Transportation and major utility corridors	659	337	456
Irrigated agriculture	28,720	215,804	6,709
Rangeland and dry agriculture	2,526,314	0	0
Major open space and parks (with water use)	5,434	2,775	456
Major open space and parks (no water use)	549,766	0	0
Natural drainage and riparian systems	42,613	148,373	3,109
Urban vacant and abandoned	20,210	0	0
Landfills and sewage treatment plants	2,954	1,508	456
Other urban non-residential	3,602	1,839	456
Kirtland Air Force Base	30,777	2,003	58
Totals:	**3,489,648**	**599,957**	

Summary of Variations

The variation-1 projection was based on the same amount of urban growth as the base-case projection, but with no loss of irrigated agriculture. Variation 1 forecasted that regional withdrawals would by approximately 784 thousand acre-feet per year. The variation-2 projection was similar to the base-case projection, but incorporated a 15 percent reduction in water withdrawals for all land-use categories except irrigated agriculture. Variation 2 forecasted that regional withdrawals would by approximately 665 thousand acre-feet per year.

The variation-3 projection was developed to estimate how much water conservation might be needed for all land-use categories except for irrigated agriculture in order to stabilize regional withdrawals at the current rate of approximately 600,000 acre-feet per year. Variation 3 used the same number of acres of irrigated agriculture as the base-case projection, and withdrawal coefficients for all other land-use categories were reduced by one third to reduce future regional withdrawals to 600,000 acre-feet per year.

Authorization

This report was prepared pursuant to Professional Services Agreements (00-550-13 and 00-550-29) between the Interstate Stream Commission and the Middle Rio Grande Council of Governments. This report documents projected future water demands for the Middle Rio Grande Water Planning region, and also includes some documentation of current water demands in the planning region. This report includes deliverables described in the scope of work for Task 1 (Water Demand Study) for the referenced contracts, including subtask 1.2 (Historical and Current Water Use, items 5, 6, and 7 of the scope of work), and subtask 1.2 (Future Water Demand, items 1 through 5 of the scope of work).

Acknowledgements

This report was partially funded by a contract from the New Mexico Interstate Stream Commission. The work was also supported by funding from the members of the Middle Rio Grande Water Resources Board, a policy board of the Middle Rio Grande Council of Governments. Professors Lowell Catlett, Jerry Hawkes, Jim Libbin, and Rhonda Skaggs in the Department of Agricultural Economics and Agricultural Business at New Mexico State University provided input on agricultural trends. Jean Witherspoon of the City of Albuquerque provided information concerning the City of Albuquerque's water supply system. Greg Olson of the City of Albuquerque provided estimates of the number of domestic wells within the City's water service area. Dee Fuerst and Colleen Logan of the City of Rio Rancho provided information on Rio Rancho's water supply system.

Jim Gross of the Middle Rio Grande Council of Governments completed much of the analysis for this report, and prepared the initial draft manuscripts. Dave Abrams, Information Services Manager at the Middle Rio Grande Council of Governments, provided demographic information and analysis. Carol Earp, GIS Analyst/Cartographer at the Middle Rio Grande Council of Governments provided cartographic and GIS support to the project. Members of the Middle Rio Grande Water Assembly and Joe Quintana of the Middle Rio Grande Council of Governments reviewed the draft report and provided useful comments to improve the report.